U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-273 014

Effect of Hydrocarbon Composition on Oxidant-Hydrocarbon Relationships. Phase I. Exhaust Blends from Non-Catalyst Equipped Vehicles

Exxon Research and Engineering Co., Linden, N.J.

Prepared for

Environmental Sciences Research Lab., Research Triangle Park, N.C.

Sep 77

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-600/3-77-109a		

4. TITLE AND SUBTITLE	5. REPORT DATE
EFFECT OF HYDROCARBON COMPOSITION ON OXIDANT-HYDROCARBON RELATIONSHIPS Phase I. Exhaust Blends from Non-Catalyst and Catalyst Equipped Vehicles	September 1977
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
T. R. Powers	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO.
Exxon Research and Engineering Company Linden, New Jersey 07036	1AA008
	11. CONTRACT/GRANT NO.
	68-02-1719
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
Environmental Sciences Research Laboratory-RTP, NC Office of Research and Development U.S. Environmental Protection Agency Research Triangle Park, NC 27711	Final
	14. SPONSORING AGENCY CODE
	EPA/600/09

15. SUPPLEMENTARY NOTES

16. ABSTRACT

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The results of these experiments indicate that the composition change due to oxidation catalysts will result in a significant alleviation, above that due to hydrocarbon concentration change alone, of the local effects of automotive tailpipe emissions.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
* Air pollution * Hydrocarbons * Ozone Automobiles * Exhaust emissions Catalytic converters Oxidation Test chambers * Irradiation		13B 18H 07C 07B 13F 21B 07A 14B

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
RELEASE TO PUBLIC	UNCLASSIFIED	155
	20. SECURITY CLASS *(This page)*	22. PRICE
	UNCLASSIFIED	PC A08 MF A01

EPA Form 2220-1 (9-73)

PB 273 014

EPA-600/3-77-106a
September 1977

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NATIONAL TECHNICAL
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EPA-600/3-77-109a
September 1977

EFFECT OF HYDROCARBON COMPOSITION ON OXIDANT-HYDROCARBON RELATIONSHIPS

Phase I. Exhaust Blends from Non-Catalyst and Catalyst Equipped Vehicles

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ABSTRACT

Oxidation catalysts on automobiles not only reduce the total amount of hydrocarbon emissions, but also change the composition of these emissions significantly. To explore the effect of this change on oxidant formation, 28 ten-hour irradiations were carried out in the Exxon Research Environmental Chamber. Fourteen of these irradiations used a hydrocarbon blend representative of the non-methane, non-acetylene exhaust hydrocarbon emissions from a non-catalyst equipped vehicle, and 14 used a blend representative of the same fraction of the emissions from a catalyst equipped vehicle. Irradiations were carried out at three hydrocarbon-to-nitrogen oxides ratios and with three modes of chamber operation, chosen to simulate different meteorological conditions.

The results of these experiments indicate that the composition change due to oxidation catalysts will result in a significant alleviation, above that due to hydrocarbon concentration change alone, of the local effects of automotive tailpipe emissions.

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SECTION 1

INTRODUCTION

The air quality standard for photochemical oxidant, 0.08 ppm, 1-hour average, not to be exceeded more than once per year, is widely regarded as the most difficult health-related standard to achieve.[1] This level is based on upper respiratory effects, as developed in the document, "Air Quality Criteria For Photochemical Oxidant". Oxidant is a secondary pollutant. That is, it is formed as a result of chemical reactions between primary pollutants, in this case, hydrocarbons (HC) and nitrogen oxides (NO_x). Air quality standards for hydrocarbons are based on the tendency of hydrocarbon to participate in reactions leading to oxidant formation. According to the Environmental Protection Agency (EPA), an air quality standard of 0.24 ppm non-methane hydrocarbon (NMHC) is required to assure that the oxidant standard is not exceeded. Most recently, a report from a National Academy of Science Panel, headed by Professor Arthur Stern, concluded that the oxidant air quality standard could be attained via a NMHC standard of 0.75 ppm carbon (ppmC). This standard is important to the nation, as the control of NMHC to very low levels in order to control oxidant may result in significant changes in our society, including urban land use, modes of transportation, and population density.

Another important recent development is the recognition that the composition of auto exhaust gas from vehicles equipped with oxidation catalysts may have a composition significantly different from that of vehicles not equipped with catalysts. The catalyst systems appear to preferentially remove the more reactive hydrocarbon species. Thus, in addition to the large reduction in total hydrocarbon mass emissions, there is a further decline in atmospheric reactivity associated with this composition change. Since hydrocarbon-oxidant relationships are affected by the photochemical reactivity of the hydrocarbon mixture, control strategies for oxidant abatement must be reevaluated in light of the prospective change which began in September, 1974 when catalyst equipped vehicles were introduced. The difference in hydrocarbon composition of the exhaust gas from these vehicles from that of vehicles not equipped with catalysts should influence the hydrocarbon-oxidant relationship.

Further investigations may show that no general, nationwide hydrocarbon-oxidant relationship is possible, since the formation of oxidant depends in part on meteorological conditions, such as ventilation, sunlight intensity, inversion layer height, etc. According to this reasoning, conditions favorable to oxidant formation in Los Angeles should not be used to establish NMHC

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[1]Due to the subject matter of this report, the English System of Units was used. For conversion to the International System of Units, see the conversion table on p. 17.

standards in New York City. Although a massive amount of aerometric data and an equally impressive array of smog chamber data have been gathered over the past decade, a clear picture of the true NMHC-oxidant relationship is still not available.

The research program reported here is designed to begin to answer some of the questions about the NMHC-oxidant relationship by providing basic data on HC-NO_x-oxidant systems at ambient concentrations, under both static and dynamic conditions. Specifically, the question of the effects of the introduction of catalytic exhaust treatment of automobile exhaust on oxidant formation is addressed in the following pages.

SECTION 2

CONCLUSIONS

While extrapolation of the results of a smog chamber study like the one reported here to the real world is subject to considerable uncertainty, it is probably justifiable to apply trends observed in smog chamber studies to actual atmospheric situations. The trends in these data indicate that significant alleviation of the local impact of automotive tailpipe emissions, above that due to changes in mass of hydrocarbons emitted, can be expected when the changeover to catalytic exhaust treatment is completed.

SECTION 3

EXPERIMENTAL PLAN

In this program, two hydrocarbon blends, one modeled on the exhaust from a non-catalyst equipped vehicle and the other on the exhaust from a vehicle meeting the 0.41 g/mi. hydrocarbon, 3.4 g/mi carbon monoxide (CO), and 0.4 g/mi. NO_x emission standards were compared using the Exxon Research Environmental Chamber. Both blends were irradiated for 10 hours in the chamber under three different initial hydrocarbon-to-NO_x (HC/NO_x) ratios and three different modes of chamber operation, as given in the matrix below:

Chamber operating mode	Initial HC/NO_x 2	4	8
static	x	x	x
dilution		x	x
dynamic		x	x

All runs were replicated. Initial hydrocarbon concentration levels were 4 ppm carbon for HC/NO_x ratios of 4 and 8, and 2 ppm carbon for an HC/NO_x ratio of 2. Initial NO_x consisted of 30% nitrogen dioxide (NO_2) and 70% nitric oxide (NO).

Time/concentration profiles for ozone (O_3), NO, NO_2, peroxyacetylnitrate (PAN), total hydrocarbons, condensation nuclei, and individual hydrocarbons were determined. Oxidant was determined by the Neutral Buffered Potassium Iodide method (NBKI) and formaldehyde was determined by the chromatropic acid method at the beginning and end of the run only. Analysis of the data has concentrated on blend-to-blend variations in those parameters of the profiles directly concerned with ozone and oxidant levels. At the request of the Project Officer, a pair of static runs was conducted using propylene at a concentration of 3 ppm carbon and an HC/NO_x ratio of 6. The purpose of the runs was to provide data for inter-chamber comparison work among EPA contractors. The data from these runs was not analyzed.

SECTION 4

METHODS AND PROCEDURES

EQUIPMENT

Experimental work was carried out using the Exxon Research Environmental Chamber facility. A description of the chamber and associated analytical methodology follows.

The Environmental Chamber

The 4.25 m^3 Exxon Research environmental chamber is made of an aluminum frame with windows of Teflon film. The chamber resembles a flattened elliptical cylinder with cross-sectional dimensions of 2.75 m x 1.83 m and a length of 0.99 m. The chamber surface is calculated to be 16.1 m^2, about 50% of which is associated with the two Teflon windows, resulting in a surface-to-volume ratio of 3.78 m^{-1}. The chamber is equipped with a metered purified air supply and metered vents which allow it to be run in dynamic modes.

Irradiation System

The irradiation system, designed to simulate ambient sunlight both in light intensity and spectral distribution of energy, consists of 80 fluorescent lamps, a combination of black and sun lamps. The light intensity in the chamber was determined by an Eppley Laboratories Model TUVR Solar Ultraviolet Radiometer (290-380 nm) to be approximately 48 mcal min^{-1} cm^{-2}.

Air Supply

An air purification system, consisting of a charcoal absorption tower and a platinum oxidation catalyst, provides pure air with less than 0.3 ppmC hydrocarbon. The hydrocarbon was analyzed and found to be solely methane. A measure of chamber background reactivity is obtained by irradiating this clean air in the chamber with humidity for 10 hours. The maximum number of condensation nuclei (CN) monitored was 182 CN/ml, which is three orders of magnitude lower than that observed with irradiated auto exhaust diluted to atmospheric levels. No increase in HC concentration was observed over the period of irradiation. Oxidant levels reach a maximum of 0.015 ppm.

CHAMBER OPERATING CHARACTERISTICS

Leak Rate and Sampling Requirements

To ensure that the chamber contents will not be contaminated by atmos-

pheric air, the chamber pressure is maintained at 0.13 kPa above atmospheric pressure. This results in an unintentional leak rate of less than 1.5% $hr.^{-1}$ which is measured by monitoring the amount of makeup air added. This volume is replaced with the purified air previously described. With the analytical procedures currently employed, the total leak rate of the chamber is about 3% $hr.^{-1}$. This volume is dependent upon the number and type of analytical measurements taken.

Relative Humidity and Temperature

The chamber is usually operated at approximately 30°C, the temperature being maintained by the use of infrared lamps. Temperature stability is adequate with a standard deviation of about 0.5°C over a 10-hour irradiation. Initial chamber humidity can be varied by circulating the diluent chamber air through a tank containing heated distilled water. The water temperature in the tank is maintained at about 80°C to reduce the time required for humidification.

Cleanliness

To ensure chamber cleanliness and avoid run-to-run contamination, the chamber is purged with pure air containing about 2 ppm ozone between experiments. This has proven to be an effective means of maintaining chamber cleanliness.

It is believed that the rate of ozone disappearance in a chamber is a measure of chamber cleanliness. Ozone disappearance rates in air at 20% relative humidity were measured with and without irradiation. These rates, expressed as the half-life for O_3 at 1 ppm, are shown below. The values compare favorably with those of other chambers.

With irradiation, $t_{1/2}$ = 2.7 hours @ 20% R.H.

Dark reaction, $t_{1/2}$ = 14 hours @ 20% R.H.

ANALYTICAL METHODOLOGY

Total Hydrocarbons

Total hydrocarbons were measured with a Varian 1440 total hydrocarbon analyzer with a sensitivity of ~10 ppbC. The analyzer was zeroed on the chamber clean air supply and spanned on a commercially analyzed cylinder of propane (0.5 ppm) in air.

Individual Hydrocarbons

Individual hydrocarbons were measured with a Perkin Elmer Model 900 Gas Chromatograph with sub-ambient temperature programming capabilities. The instrument was equipped with a column 1/8" outer diameter (O.D)., 5% UCW 98 on 80/100 mesh Chromosorb G AWDMCS. Fifty milliter samples were injected at -70°C and the column oven temperature was raised at a rate of 8°C/min. to 180°C. The instrument is calibrated on the initial chamber hydrocarbon

charge, which is a metered dilution of a commercially analyzed cylinder.

Nitrogen Oxides

Nitrogen oxides were monitored with a TECO 14B nitrogen oxides analyzer. The analyzer is calibrated on a commercially analyzed cylinder using a TECO Model 101 calibration unit.

Oxidants

Oxidants were determined by the Neutral Buffered Potassium Iodide Procedure according to the Federal Reference Method (Fed. Reg. Vol. 36, #84, p. 8196), and corrected for NO_2 by subtracting 0.1 $[NO_2]$.

Ozone

Ozone was measured with a REM Chemiluminescent Analyzer calibrated on the ozone generator in the TECO 101 calibration unit. The ozone generator is calibrated by Neutral Buffered Potassium Iodide according to the Federal Reference Method.

Peroxyacetylnitrate

Peroxyacetylnitrate determinations were carried out with a Varian Model 1700 gas chromatograph with electron capture detector. Calibration is by dilution of PAN mixtures synthesized in-house. Concentration of these mixtures is determined by long path infrared spectroscopy.

Formaldehyde

Formaldehyde concentrations were determined by the chromatropic acid method (U.S. Dept. HEW, 999-AP-11).

Condensation Nuclei

Condensation nuclei were monitored with an Environment One Condensation Nuclei Monitor, which operates on the cloud chamber principle.

REAGENTS AND CALIBRATION GASES

All reagents and calibration gases were obtained as analyzed cylinders from Scott Research Laboratories in Plumsteadville, Pennsylvania and used without further purification.

Nitrogen Oxides

Separate cylinders of NO_2 ($\sim$1000 ppm in hydrocarbon-free nitrogen) and NO ($\sim$1000 ppm in hydrocarbon-free nitrogen) were used to charge NO_x for all runs.

Hydrocarbon Blend

Two different hydrocarbon blends were used in this study. Blend XL-228 is a model blend for the non-methane, non-acetylene hydrocarbon fraction of the

exhaust from a non-catalyst equipped vehicle. Blend A-11004 is a model blend for the same fraction of the exhaust from a car meeting stringent (0.41 g/mi. HC, 3.4 g/mi. CO, 0.4 g/mi. NO_x) emission standards.

Hydrocarbon blends were derived from gas chromatographic data on auto exhaust obtained at Exxon Research and Engineering. Details of these blends are given in Table 1.

For a non-catalyst equipped car, two runs were used. These were analyses of the emissions from a 1970 Chevrolet with a 5.7 liter engine run on the 1972 Federal Test Procedure. For the catalyst equipped car data, three runs from another 1970 5.7 liter Chevrolet equipped with a Monel reduction catalyst before a monolithic oxidation catalyst were used. This vehicle was run on the 1975 Federal Test Procedure. Both cars were run on a 37% aromatic fuel blended from standard refinery blending components. The olefin data were not used as they were believed to be unrepresentative due to a large and probably spurious trans-hexene-2 peak.

Using the summary of mole fraction data from each run, the following parameters were calculated for non-catalyst equipped and catalyst equipped emissions: average mole fractions of non-methane paraffins, olefins and aromatics; average carbon numbers of the whole mixture, non-methane paraffins, olefins, and aromatics; the ratio of C_2 olefins to C_3 olefins; and the ratio of C_7 aromatics to C_8 aromatics. The blends were constructed as follows:

Paraffins: The normal paraffin of carbon number closest to the average non-methane paraffin carbon number was chosen and put in at the average non-methane paraffin mole fraction.

Olefins: Ethylene and propylene were chosen as olefin model compounds and put at the C_2 and C_3 olefin ratio calculated from the data. Total mole fraction of olefins was set at the value derived from the data.

Aromatics: Toluene and xylene were chosen as aromatic model compounds and put in at the C_7 to C_8 aromatic ratio calculated from the data. Total mole fraction of aromatics was set at the value derived from the data.

Table 1 gives values of all the parameters calculated from the data, and also gives values of the same parameters calculated from the blends used in this work. The blends provide a good approximation to the available data on non-methane, non-acetylene emissions from non-catalyst equipped and catalyst equipped cars.

PROCEDURE

After an overnight flush with clean air, the chamber was pressurized to 0.13 kPa and checked for background ozone, oxidant, hydrocarbon, and NO_x. If these values were essentially zero, chamber humidity was set and the chamber

TABLE 1. HYDROCARBON BLENDS AND CALCULATED PARAMETERS

HYDROCARBON BLENDS

Compounds	Mole Fraction (Non-Catalyst Equipped Car) XL-228	(Catalyst Equipped Car) A-11004
n-pentane	0.21	—
n-butane	—	0.51
ethylene	0.30	0.18
propylene	0.09	0.04
toluene	0.17	0.17
m-xylene	0.23	0.10

CALCULATED PARAMETERS

Parameter	Non-Catalyst Equipped Car Experimental	XL-228	Catalyst Equipped Car Experimental	A-11004
mole fraction paraffins	.19	.21	.53	.51
mole fraction olefins	.44	.39	.21	.22
mole fraction aromatics	.38	.40	.25	.27
avg. paraffin carbon number	5.06	5.00	4.44	4.00
avg. olefin carbon number	2.35	2.22	2.47	2.18
avg. aromatic carbon number	7.88	7.57	7.30	7.41
avg. carbon number	4.94	4.95	4.73	4.52
C_2/C_3 olefin ratio	3.3	3.3	4.74	4.5
C_7/C_8 aromatic ratio	.78	.71	1.62	1.70

Avg. Carbon Number Ratio Non-Catalyst Equipped/Catalyst Equipped	
Experimental	1.04
Blends	1.09

was charged to the initial reactant levels in the following order:

1) NO_2 (to 30% of total NO_x)*

2) NO (balance of total NO_x)

3) hydrocarbon

Initial readings of all instruments were taken after charging and before turning on the lights. Instruments were read at half-hour intervals for the first 5 hours of each run and at hourly intervals for the second 5 hours. Oxidant and formaldehyde were determined only at the end of the run after the lights had been shut off. Three different modes of chamber operation were used:

- Static - Only air necessary to make up for samplings losses was added. Results were corrected for this small dilution before reporting. Initial relative humidity was set at 12%.**

- Dilution - The chamber was operated statically for the first 5 hours of irradiation and then diluted at a rate of 10%/hour with purified air. This mode was intended to simulate a temperature inversion which holds throughout the morning and then breaks up. Results were not corrected for dilution. Initial relative humidity was set at 20%.**

- Dynamic - The chamber charge was diluted at a rate 10%/hour from the beginning of the run with purified air and reactants at a concentration 0.4 ppmC hydrocarbon and 0.1 ppm NO. This mode was intended to represent the transport of a polluted air mass across a populated area where it is diluted and simultaneously receives injections of reactants. Results were not corrected for dilution. Initial relative humidity was set at 70%.**

At the end of each run, the chamber was flushed for 8 hours with clean air, treated with ozone at ~2 ppm for 2 hours with the lights on and flushed overnight with clean air. To facilitate the determination of statistically significant trends in the data, runs were performed in random order.

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*except propylene runs, where all NO_x was charged as NO.

**Due to an arithmetical error, average relative humidity was not held constant over all running modes, so effects due to change in running mode may be, in part, due to differences in relative humidity.

SECTION 5

RESULTS AND DISCUSSION

DATA ORGANIZATION AND PRESENTATION

Raw data from each chamber run were punched on cards and fed into an IBM 1130 computer. The computer converted the raw instrument readings into concentrations in ppm, corrected these concentrations for dilution as necessary, and output the results in graphical form. Smooth curves were drawn through the line printer plots from the computer and further parameters were calculated from these curves. The formulae used to calculate these parameters are listed in Appendix A. The computer output sheets are available from the Project Officer. Calculated parameters and graphs for all runs appear in Appendices B and C.

Propylene Runs

Two static runs using propylene were made at an initial concentration of 3 ppmC and an HC/NO_x ratio of 6 in order to facilitate inter-chamber comparisons among EPA contractors. The low level of O_3 production in these runs and in preliminary runs with our test hydrocarbon blends indicated that there was a deficiency in light intensity in the chamber. Modifications were made to the windows and light banks to correct this deficiency. Since the propylene runs do not reflect the condition of the chamber during the balance of the program, no further analysis was performed. For the sake of completeness, the graphs and calculated parameters for the runs are in Appendix B. The computer output sheets are available from the Project Officer.

Runs at $HC/NO_x = 2$

Runs at this level showed no evidence of reaction with either blend; therefore, they were not analyzed further.

Runs at $HC/NO_x = 4$ and $HC/NO_x = 8$

Runs at these levels showed evidence of reaction with both blends and in all chamber operating modes. All of the subsequent analyses and conclusions are based on these runs. For the sake of completeness, the graphs and calculated parameters for the runs are in Appendix C. The computer output sheets are available from the Project Officer.

Condensation Nuclei Data

Condensation nuclei concentrations (CNC) were of the order of 10^2/ml for all runs. This extremely low absolute concentration level is near the limits of detectability for our CNC counter. It is believed that any variability in CNC readings is due to the noise inherent in operating the instrument at these low levels, so no detailed analysis of these data was carried out.

DATA ANALYSIS

The 24 runs with $HC/NO_x = 4$, and $HC/NO_x = 8$, chamber running conditions of static, dilution, and dynamic, and non-catalyst equipped and catalyst equipped hydrocarbon blends form a completely replicated 3 x 2 x 2 factorial experimental design. One of the basic characteristics of this design is that factor effects, i.e., those due to HC/NO_x, chamber running conditions, or hydrocarbon blend, are completely clear of each other. The factor effects are also clear of all two- and three-factor interaction effects and the interaction effects are clear of each other. Replication allows the variance in the measurements to be estimated and the statistical significance of any observed effects to be determined.

For these data, a three-factor analysis of variance was carried out for the parameters in Table 2. (The analysis of variance tables are given in Appendix D.) This group includes all of the parameters necessary to make a good assessment of the effects of the factors in the experimental matrix on photochemical smog production. All of the single factor and two-way interaction effects significant at the 95% level were determined using the standard F test for comparison of the variance due to the factor and the variance determined from the replicate experiments. These significant effects are given below.

It should be noted that very little significance can be attached to the absence of an effect in this analysis. The experimental design and variance of the measurements are such that the probability of not detecting an effect of .03 ppm in maximum O_3, maximum NO_2, or final oxidant is ~50% when the test for that effect is carried out at the 95% significance level.

RESULTS

Effects Due Only to Hydrocarbon Blend

Changing the hydrocarbon blend from non-catalyst equipped to catalyst equipped (XL-228 to A-11004):

- Decreased the maximum 1-hour average ozone concentration by 39%, from an average of .23 ppm to an average of .14 ppm.
- Increased the time to reach maximum ozone 33%, from an average of 5.4 hrs. to an average of 7.2 hrs.
- Decreased maximum PAN concentration 53%, from an average of 0.015 ppm to an average of 0.007 ppm.

TABLE 2. PARAMETERS ANALYZED

Ozone, maximum 1-hour average
Ozone dose
Ozone, time to maximum
NO_2, maximum 1-hour average
NO_2, dose
NO_2, time to maximum
PAN, maximum
Oxidant, final
Formaldehyde, final
Total Hydrocarbon, average disappearance rate
Individual Hydrocarbon, average disappearance rate*

* Analyzed by simple analysis of variance for compound-to-compound differences as missing data did not allow a full factor analysis.

- Decreased the average total hydrocarbon disappearance rate 38%, from an average of 0.88 ppm/hr. to an average of 0.54 ppm/hr.

Effects Due Only to Change in HC/NO_x Ratio

Changing the HC/NO_x ratio from 4 to 8 (or NO_x concentration from 1.0 ppm to 0.5 ppm):

- Decreased time to maximum ozone by 26%, from 7.2 hrs. to 5.4 hrs.
- Decreased NO_2 1-hour maximum average by 36%, from 0.45 ppm to 0.29 ppm.
- Decreased NO_2 dose by 43%, from 2.8 ppm hrs. to 1.6 ppm hrs.

It should be noted that in this set of experiments, HC concentration was held constant. Therefore, a change in HC ratio may equally be thought of as a change in total NO_x concentration.

Effects Due Only to Change in Chamber Running Mode

A change in chamber running conditions from static to dynamic:

- Increased maximum 1-hour average ozone 39%, from an average of .18 ppm to an average of .25 ppm.
- Decreased time to maximum ozone 60%, from an average of 8.7 hrs. to an average of 3.5 hrs.
- Decreased time to maximum NO_2 by 70%, from 2.2 hrs. to 0.7 hrs.
- Increased maximum PAN concentration 171%, from an average of .007 ppm to an average of .019 ppm.
- Increased average total hydrocarbon disappearance rate 272%, from an average of .36 ppm/hr. to an average of 1.34 ppm/hr.

Effects Due to Interactions Between Hydrocarbon Blend and HC/NO_x Ratio

Increasing initial HC/NO_x from 4 to 8 left final oxidant concentration unchanged for Blend XL-228 (non-catalyst) and increased final oxidant by 83% for Blend A-11004 (catalyst).

Effects Due to Interactions Between Hydrocarbon Blend and Chamber Running Mode

Changing hydrocarbon blend from XL-228 (non-catalyst) to A-11004 (catalyst) increased time to maximum ozone:

- 19% for static runs, from an average of 8.0 to an average of 9.5.

- 55% for dilution runs, from an average of 5.2 to an average of 8.1.
- 33% for dynamic runs, from an average of 3.0 to an average of 4.0.

Effects Due to Interactions Between HC/NO_x Ratio and Chamber Running Mode

Increasing HC/NO_x from 4 to 8:

- Decreased maximum PAN 40% for static runs, from an average of 0.010 to an average of 0.006.
- Increased maximum PAN 150% for dilution runs, from an average of 0.004 to an average of 0.010.
- Decreased maximum PAN 14% for dynamic runs, from an average of 0.021 to an average of 0.018.
- Increased average 1-hour maximum average O_3 100% for dilution runs, leaving it unchanged for static and dynamic runs.

Notes on Dosages

Dosage calculations, being integrals under experimental curves, are highly dependent upon the time limits of the integration. Comparisons based on total dose are subject to an experimental artifact: if the effect of a change in experimental factor is to shift the O_3 or NO_2 maxima to a later time, and the dose integral is still cut off in 10 hours from the start of the run, the dose will be less, but it will be less because the production was artifically terminated at the end of the run. To guard against this artifact, no effects on dose are reported as significant unless the factor involved had no effect on the time to maximum of the species in question.

DISCUSSION

Examination of the large number of statistically significant effects shows that the findings of this study can be easily summarized.

The effects due to hydrocarbon blend, i.e., a decrease in maximum 1-hour average ozone and an increase in the time to reach it, a decrease in maximum PAN, and a decrease in total hydrocarbon disappearance rate, can all be thought of as effects which tend to lessen the short term (<10 hour) severity of photochemical smog as one goes to the catalyst blend.

The behavior of the system in response to changes in HC/NO_x ratio (or equivalently in this study, NO_x level) is also quite simple. The only effects found were a decrease in NO_2 levels with decreasing NO_x and a decrease in time to maximum ozone with decreasing NO_x.

The behavior of the system in response to changes in chamber running mode is also of interest. The most severe short term smog effects did not occur under static or stagnant conditions but under dynamic conditions where con-

siderable dilution of the air mass takes place. This dilution is contaminated by air with a low level of hydrocarbons and NO. This finding has implications for control strategy formulation also as it indicates that a good assessment of the potential severity of smog in a given day must consider the effects of input precursors throughout the day as well as the effects of the precursors present in the early morning.

The results of this study can then be stated in the following summary:

Changing hydrocarbon composition from a blend modeled on exhaust from a non-catalyst equipped vehicle to a blend modeled on exhaust from a catalyst equipped vehicle decreases the parameters associated with the short term (<10 hour) severity of photochemical smog.

Changing the hydrocarbon-to-NO_x ratio from 4 to 8 decreases the time to O_3 maximum, the maximum 1-hour average NO_2, and the NO_2 dosage.

Short term (<10 hour) smog effects are most severe under dynamic running conditions.

TABLE 3. CONVERSION TABLE TO S. I. UNITS

To Convert From	To	Multiply by
calorie	joule	4.186 8 E+00
gram	kilogram	1.000 000*E-03
hour	second	3.600 000*E+03
kilopascals (kPa)	newton/meter^2	1.000 000*E+03
liter	meter^3	1.000 000*E-03
mile	meter	1.609 344*E+03
minute	second	6.000 000*E+01
degree Celsius (°C)	degree Kelvin (°K)	$t_k = t_c + 273.15$

APPENDIX A

FORMULAE USED TO CALCULATE PARAMETERS

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K_D = NO_2 photolysis rate constant

$$K_D = \frac{[NO]\,[O_3]}{[NO_2]}\ (29.5)\ min^{-1}\ *$$

where all concentrations are determined at the intersection point of the NO and O_3 curves.

$$NO_2\ Dose = \int_0^{10} [NO_2]\ dt\ ppm\ hrs.$$

$$O_3\ Dose = \int_0^{10} [O_3]\ dt\ ppm\ hrs.$$

**O_3 maximum 1-hour average =

$$\frac{O_3(max) + O_3(1/2\ hr.\ before\ max) + O_3(1/2\ hr.\ after\ max)}{3}$$

**NO_2 maximum 1-hour average =

$$\frac{NO_2(max) + NO_2(1/2\ hr.\ before\ max) + O_3(1/2\ hr.\ after\ max)}{3}$$

The project officer provided the following formulae:

$$NO_2\ formation\ rate = \frac{NO\ initial}{2T_{1/2}}\ ppm/hr.$$

where

$T_{1/2}$ = time at which NO_2 = 1/2 NO initial + NO_2 initial

$$Maximum\ rate\ of\ O_3\ formation = \frac{O_3(max)}{2\,(T_{3/4} - T_{1/4})}$$

---

* This formula is from: O'Brian, Environ. Sci. Tech., 8, 579, 1974.
**The formulae provide a good approximation to the true average for the broad maxima encountered in this work.

where

$T_{3/4}$ = time to form 3/4 of O_3 (max)

$T_{1/2}$ = time to form 1/4 of O_3 (max)

Average rate of O_3 formation = $\frac{O_3(max)}{2\ T_{1/2}}$

where

$T_{1/2}$ = time to form 1/2 of O_3 (max)

Maximum rate of hydrocarbon disappearance = $\frac{HC_i - HC_f}{2\ (T_{3/4} - T_{1/4})}$

where

HC_i = initial hydrocarbon concentration

HC_f = final hydrocarbon concentration

$T_{3/4}$ = time for disappearance of 3/4 (IHC_i - THC_f)

$T_{1/4}$ = time for disappearance of 1/4 (IHC_i - THC_f)

APPENDIX B

CALCULATED PARAMETERS AND GRAPHS
UNANALYZED RUNS

Propylene at 3 ppmC, $HC/NO_x = 6$

XL-228 (Non-catalyst blend) at 2 ppmC, $HC/NO_x = 2$

A-11004 (Catalyst blend) at 2 ppmC, $HC/NO_x = 2$

Note: The E field specification (floating point) notation was used for the ordinate and abcissa values on the graphs in this appendix. Explanation of notation:

$$0E\ -1 = 0 \times 10^{-1}$$

$$0E\ 1 = 0 \times 10^{-1}$$

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RUN NO. 9C: 3 ppmC PROPYLENE, 0.5 ppm NO, STATIC
FEBRUARY 4, 1975

Average Temperature = 31.25 ± 0.15 °C

Average Dilution Rate = $0.227 \times 10^{-1} \pm 0.153 \times 10^{-2}$ hr^{-1} chamber volumes

Concentrations are corrected for dilution

NO_2 Photolysis Rate Constant = 1.27 min^{-1}

NO_2 Formation Rate = 0.31 ppm hr^{-1}

NO_2 Dose = 1.883 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.22 ppm hr^{-1}

Average Rate of O_3 Formation = 0.10 ppm hr^{-1}

O_3 Dose = 1.678 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.28 ppmC hr^{-1}

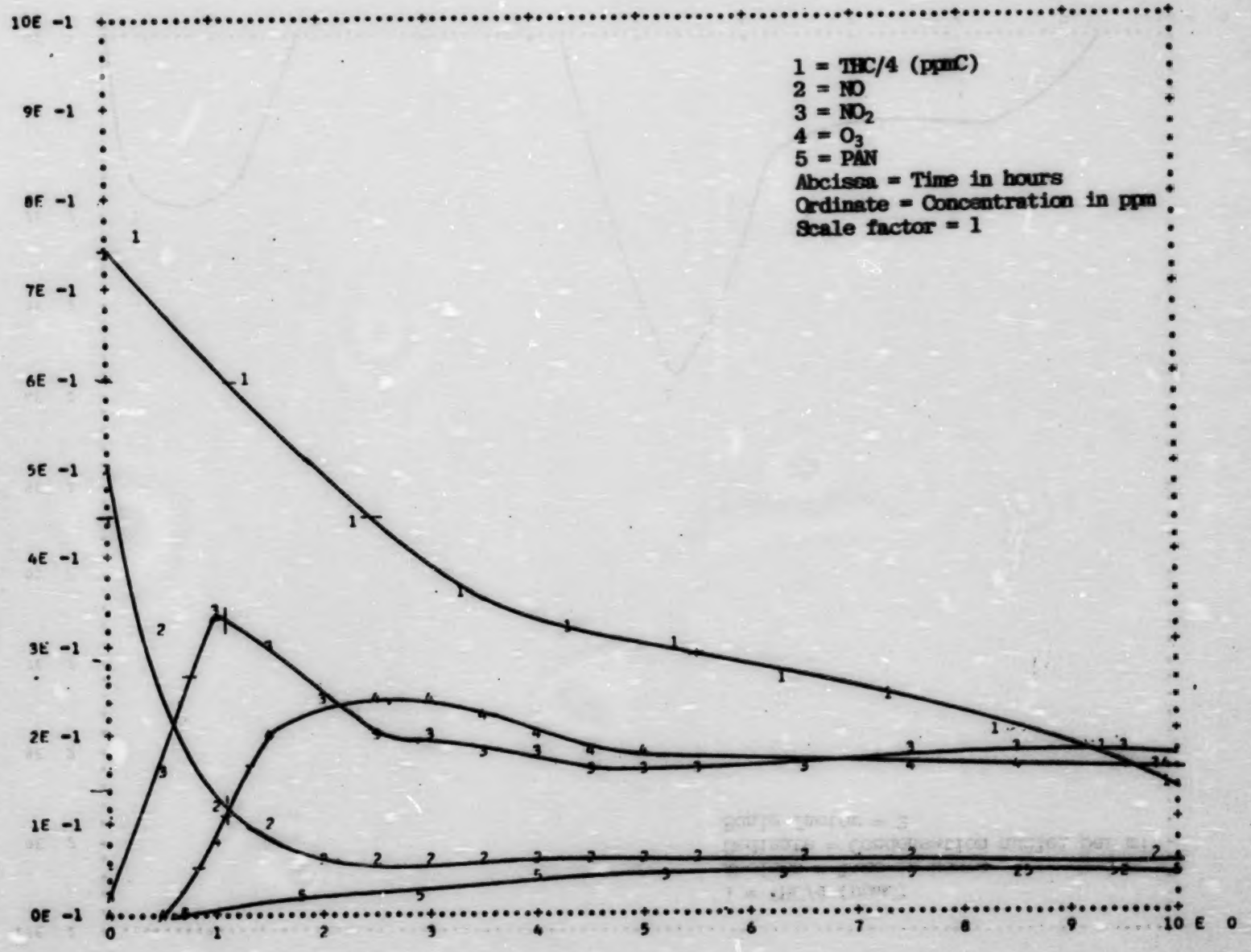
Average Rate of Total Hydrocarbon Disappearance = 0.50 ppmC hr^{-1}

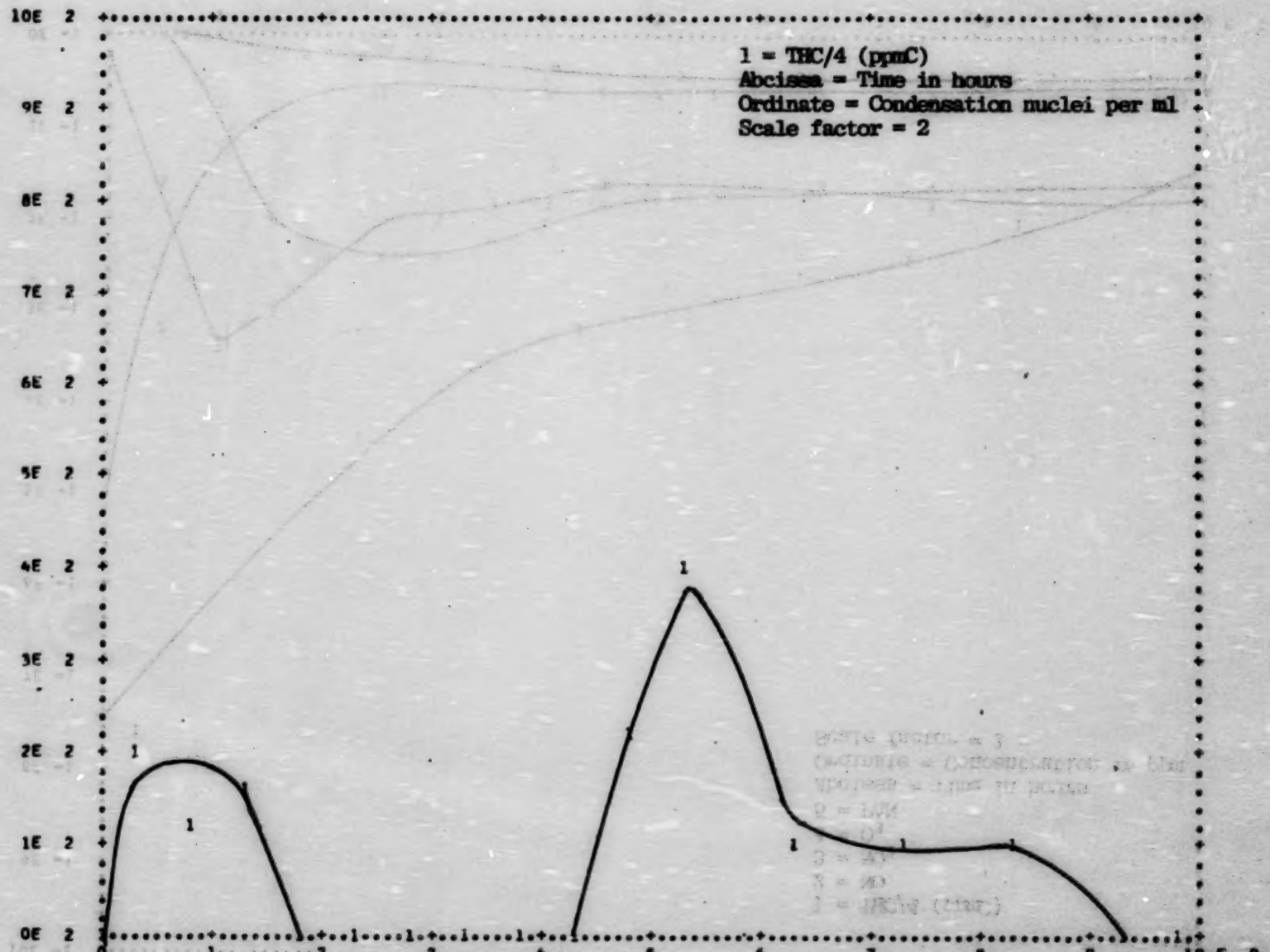
Initial Oxidant by Neutral Buffered KI = 0.02 ppm

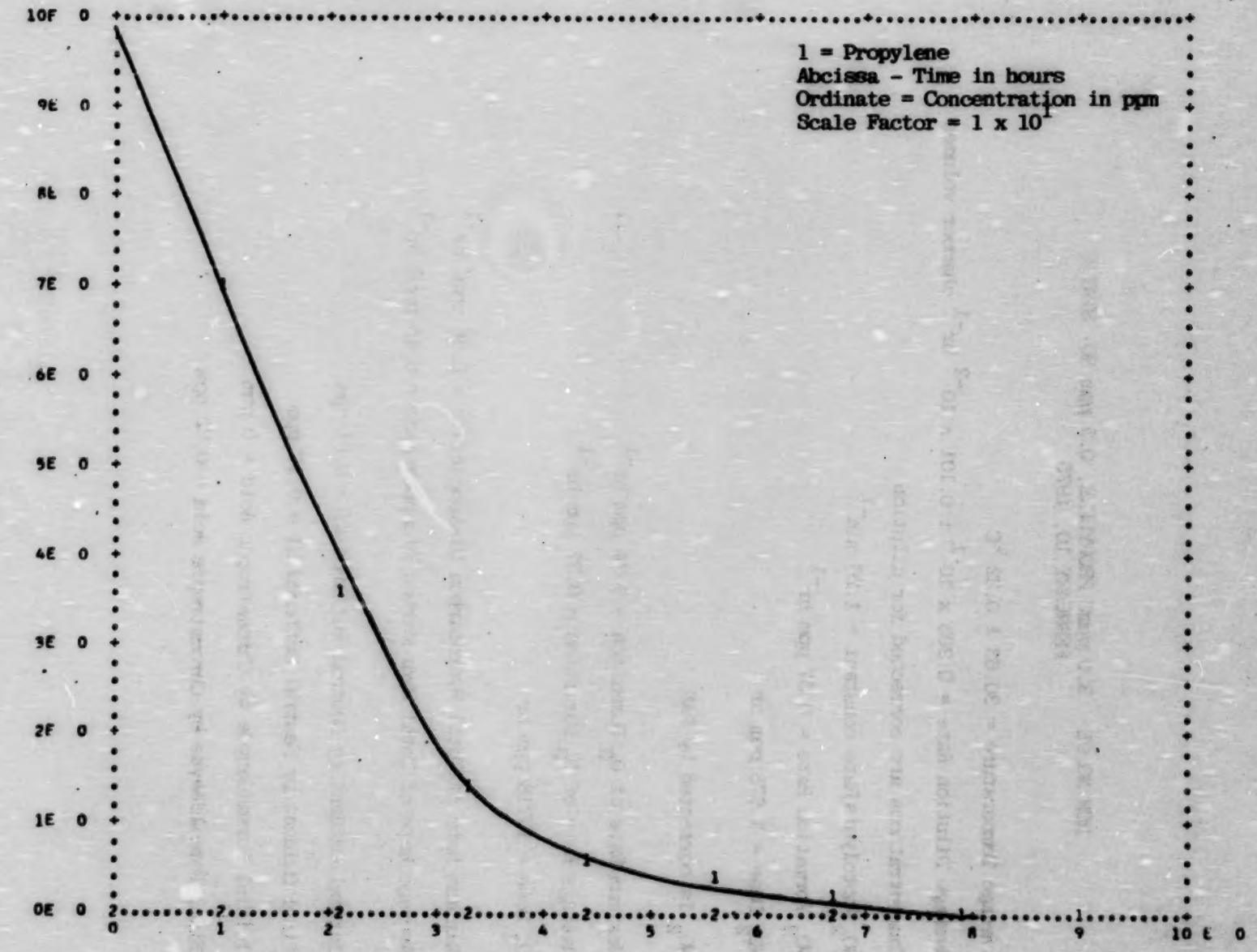
Final Oxidant by Neutral Buffered KI = 0.16 ppm

Initial Formaldehyde by Chromatropic Acid = 0 ppm

Final Formaldehyde by Chromatropic Acid = 0.45 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0
1
2
3
4
5
6
7
8
9
10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 2
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0
1
2
3
4
5
6
7
8
9
10 E 0


1 = Propylene
Abcissa - Time in hours
Ordinate = Concentration in ppm
Scale Factor = 1 x 10
10F 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2F 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0

RUN NO. 9E: 3.0 ppmC PROPYLENE, 0.5 ppm NO, STATIC
FEBRUARY 10, 1975

Average Temperature = 30.63 ± 0.32 ^{o}C

Average Dilution Rate = $0.203 \times 10^{-1} \pm 0.101 \times 10^{-2}$ hr^{-1} chamber volumes

Concentrations are corrected for dilution

NO_2 Photolysis Rate constant = 1.26 min^{-1}

NO_2 Formation Rate = 0.57 ppm hr^{-1}

NO_2 Dose = 1.678 ppm hr

NO_2 is corrected by PAN

Maximum Rate of O_3 Formation = 0.34 ppm hr^{-1}

Average Rate of O_3 Formation = 0.27 ppm hr^{-1}

O_3 Dose = 1.718 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.46 ppmC hr^{-1}

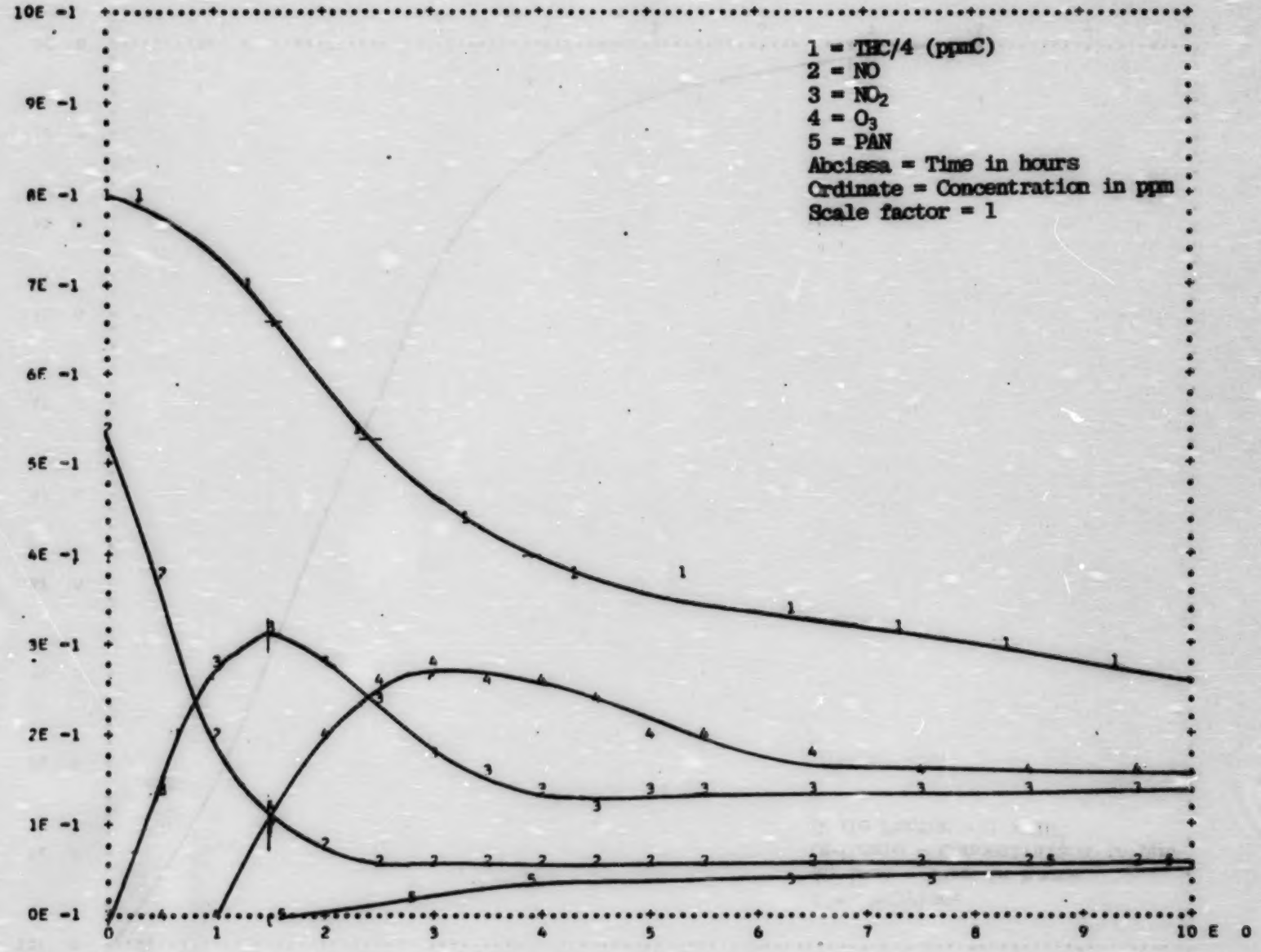
Average Rate of Total Hydrocarbon Disappearance = 0.45 ppmC hr^{-1}

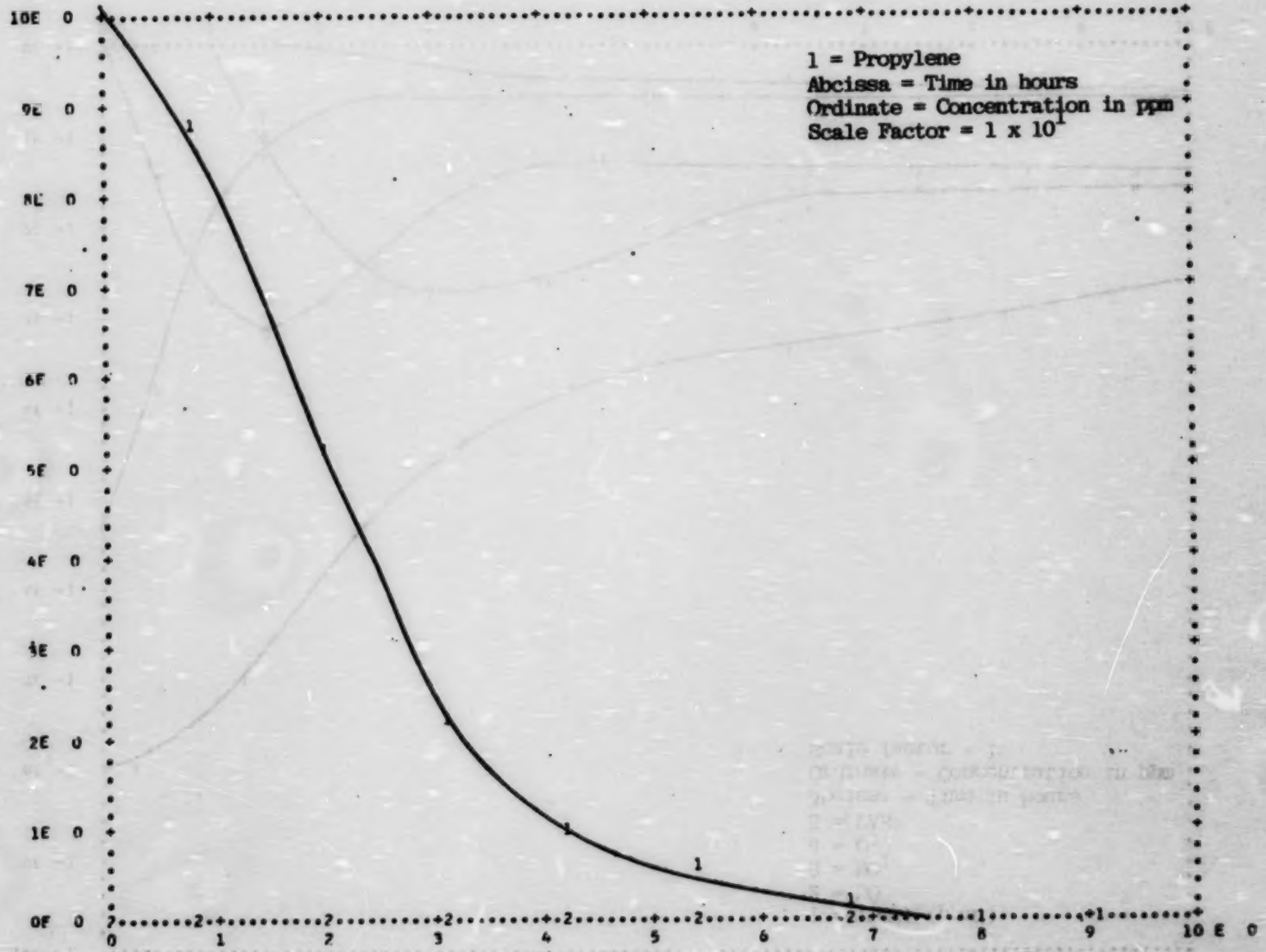
Initial Oxidant by Neutral Buffered KI = 0.01 ppm

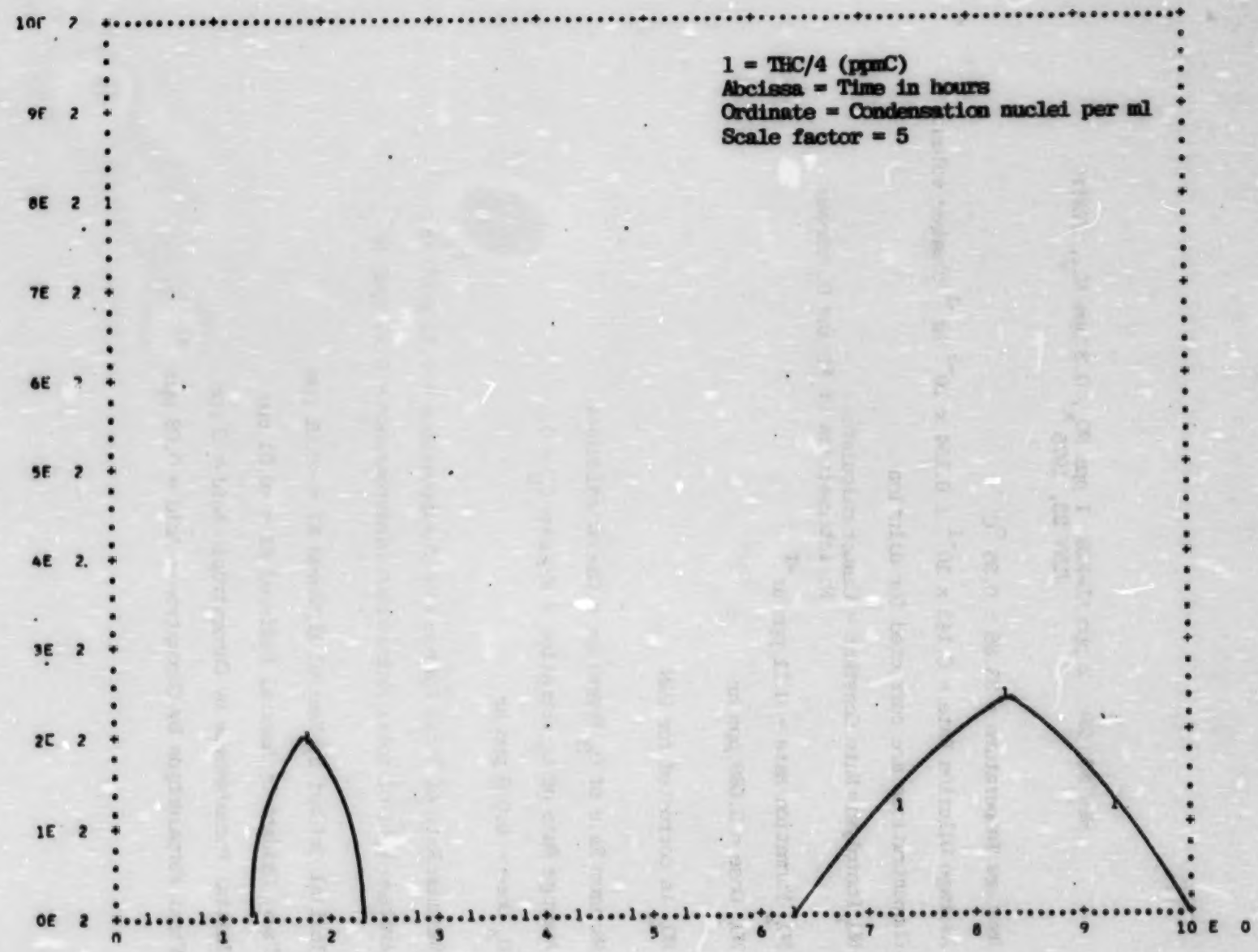
Final Oxidant by Neutral Buffered KI = 0.17 ppm

Initial Formaldehyde by Chromatropic Acid = 0 ppm

Final Formaldehyde by Chromatropic Acid = 0.72 ppm


10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0
1
2
3
4
5
6
7
8
9
10 E 0
1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1


1 = Propylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale Factor = 1 x 10
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 5
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0 1 2 3 4 5 6 7 8 9 10 E 0

RUN NO. 20: 2 ppm XL-228, 1 ppm NO_x, 0.3 ppm NO_2, STATIC
JUNE 23, 1975

Average Temperature = 33.86 ± 0.35 °C

Average Dilution Rate = $0.143 \times 10^{-1} \pm 0.154 \times 10^{-2}$ hr^{-1} chamber volumes

Concentrations are corrected for dilution

NO_2 Photolysis Rate Constant = Cannot calculate.
No intersection of NO and O_3 curves.

NO_2 Formation Rate = 0.11 ppm hr^{-1}

NO_2 Dose = 3.089 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = Cannot calculate.

Average Rate of O_3 Formation = Maximum O_3 = 0.

O_3 Dose = 0.016 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.11 ppmC hr^{-1}

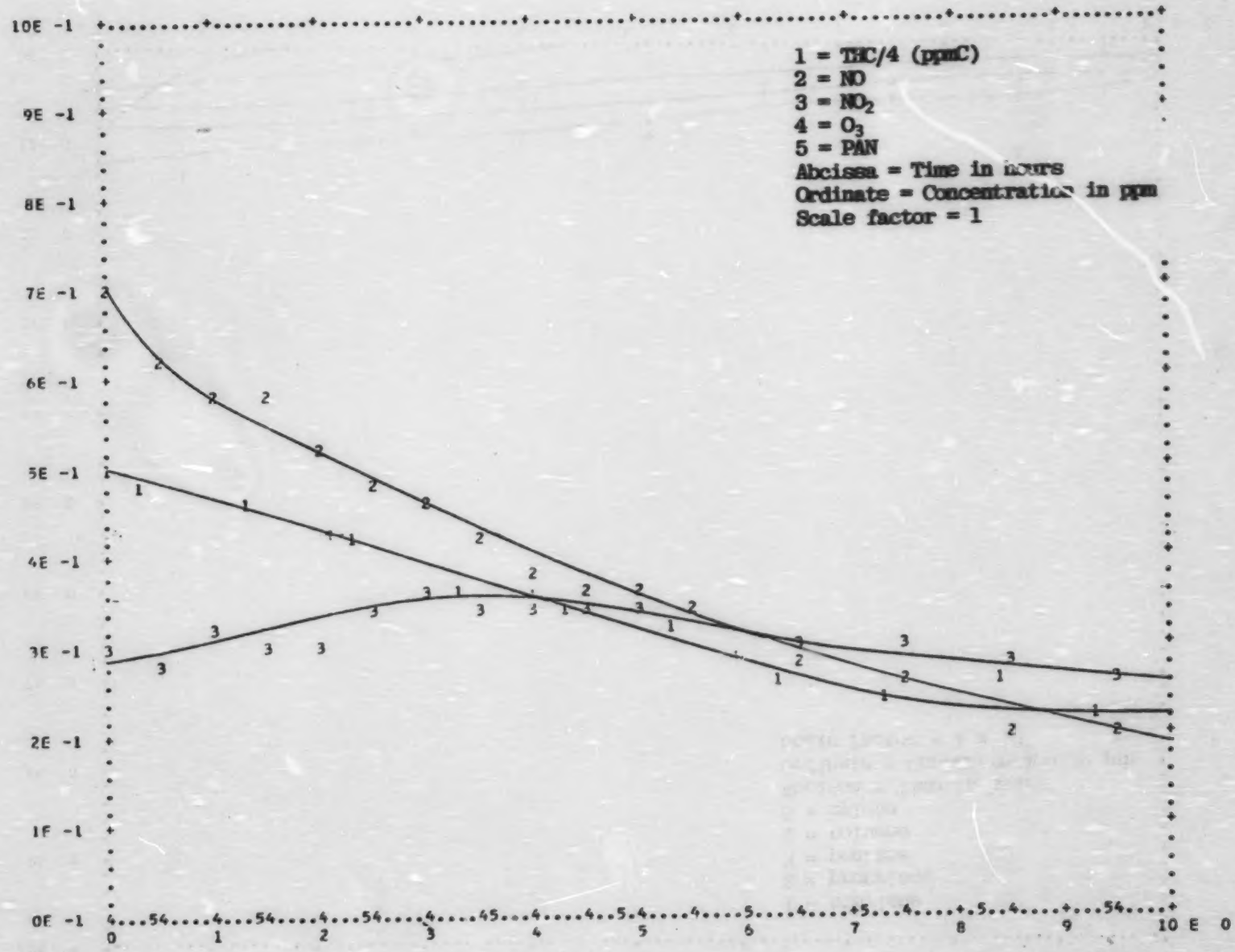
Average Rate of total Hydrocarbon Disappearance = 0.14 ppmC hr^{-1}

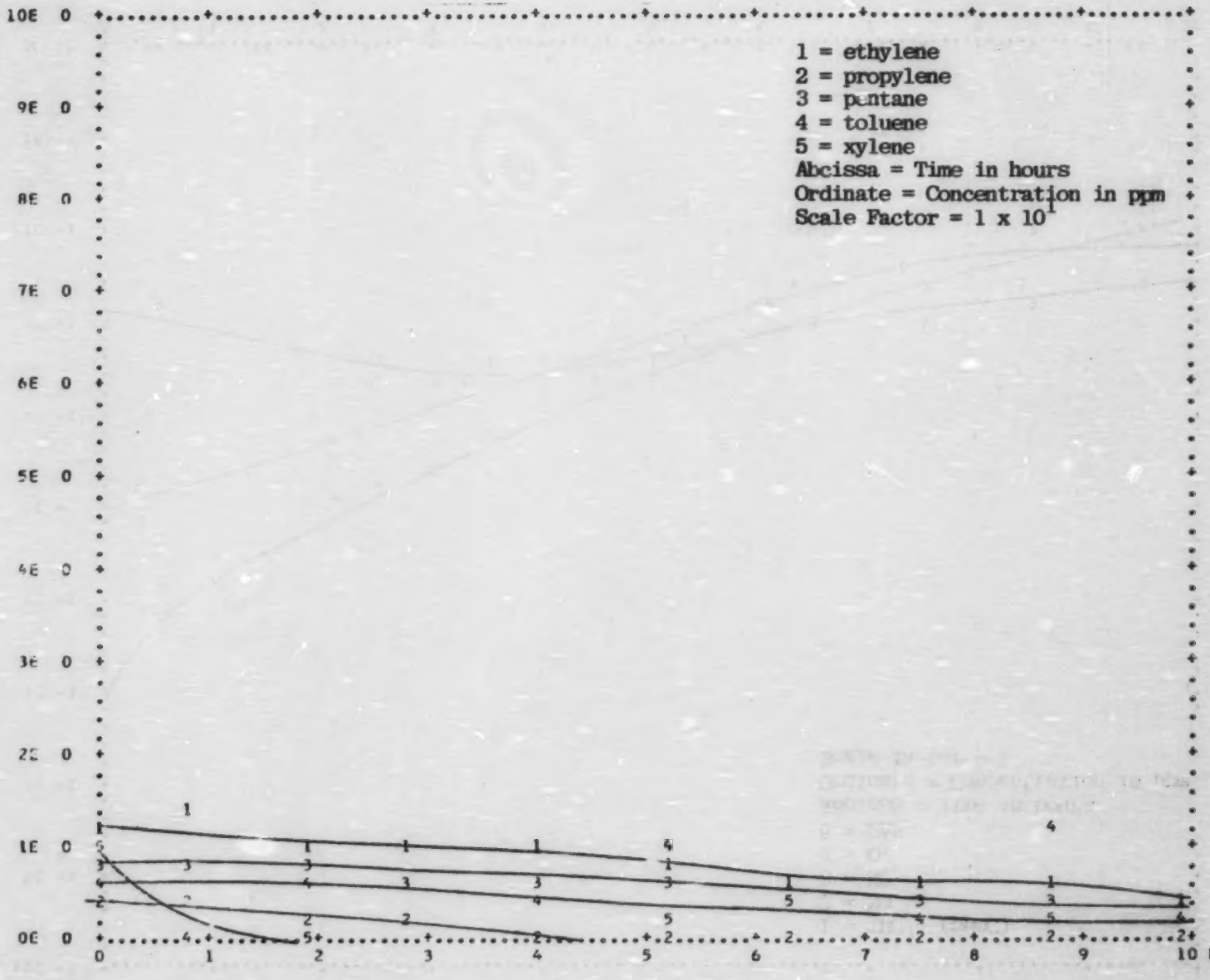
Initial Oxidant by Neutral Buffered KI = <0.01 ppm

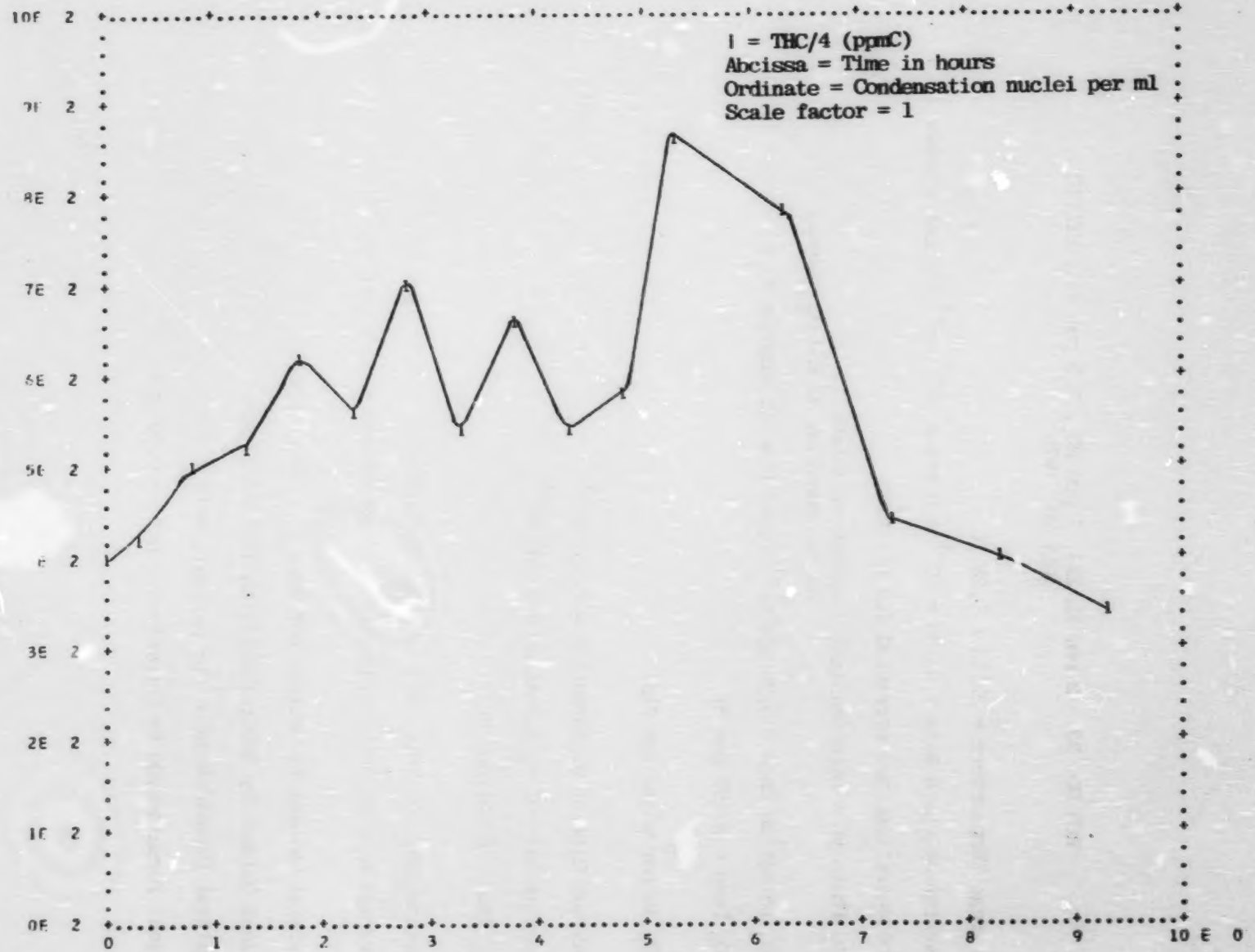
Final Oxidant by Neutral Buffered KI = <0.01 ppm

Initial Formaldehyde by Chromatropic Acid = 0 ppm

Final Formaldehyde by Chromatropic Acid = 0.08 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0
1
2
3
4
5
6
7
8
9
10 E 0


1 = ethylene
2 = propylene
3 = pentane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale Factor = 1 x 10^1
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 1
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0
1
2
3
4
5
6
7
8
9
10 E 0

RUN NO. 32: 2 ppm XL-228, 1 ppm NO_x, 0.3 ppm NO_2, STATIC
JULY 25, 1975

Average Temperature = 33.18 ± 0.28 °C

Average Dilution Rate = $0.136 \times 10^{-1} \pm 0.814 \times 10^{-3}$ hr^{-1} chamber volumes

Concentrations are corrected for dilution

NO_2 Photolysis Rate Constant = Cannot calculate.
No intersection NO and O_3 curves.

NO_2 Formation Rate = 0.30 ppm hr^{-1} (used time at maximum NO_2).

NO_2 Dose = 3.197 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0 ppm hr^{-1}

Average Rate of O_3 Formation = 0 ppm hr^{-1}

O_3 Dose = 0.004 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.15 ppmC hr^{-1}

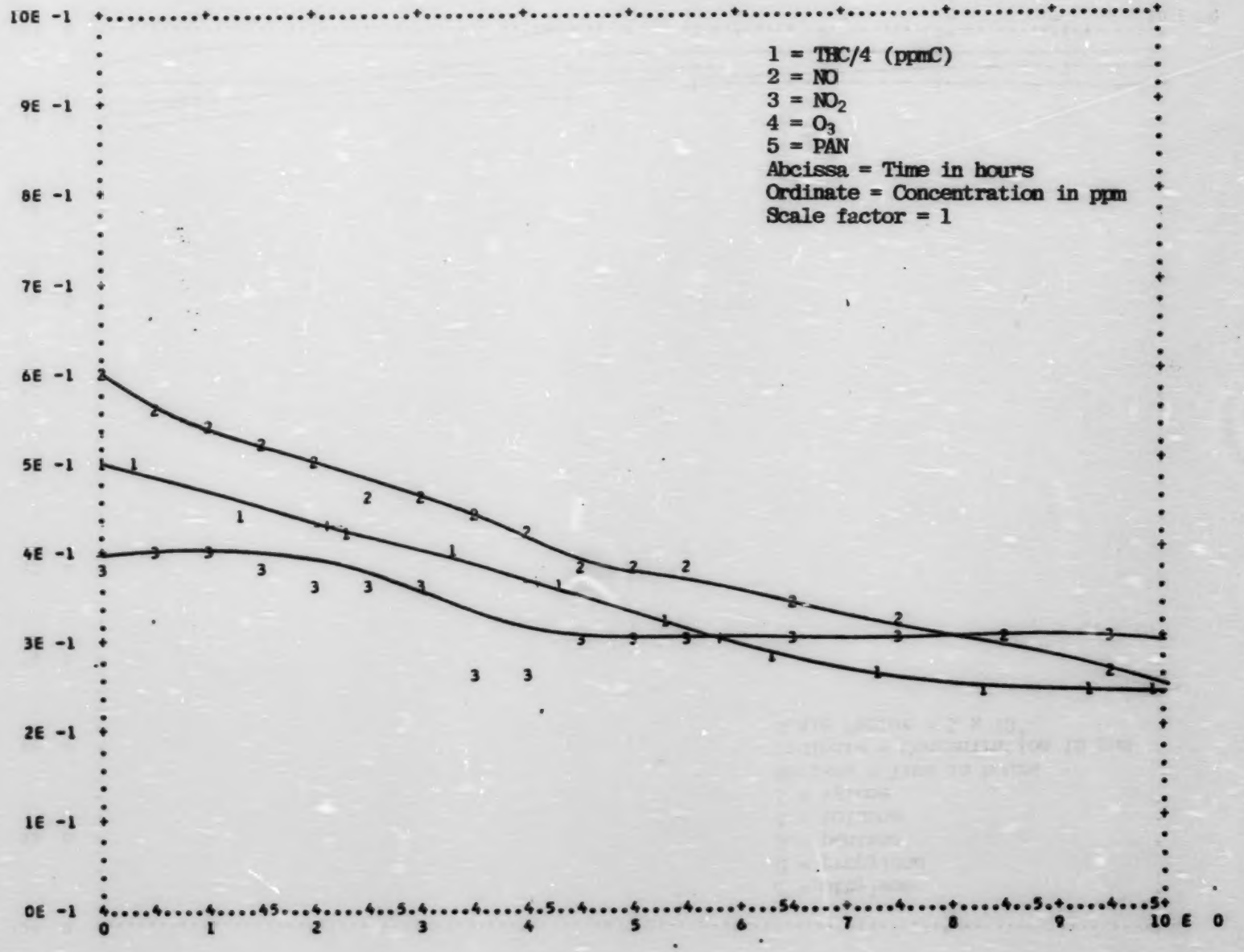
Average Rate of Total Hydrocarbon Disappearance = 0.13 ppmC hr^{-1}

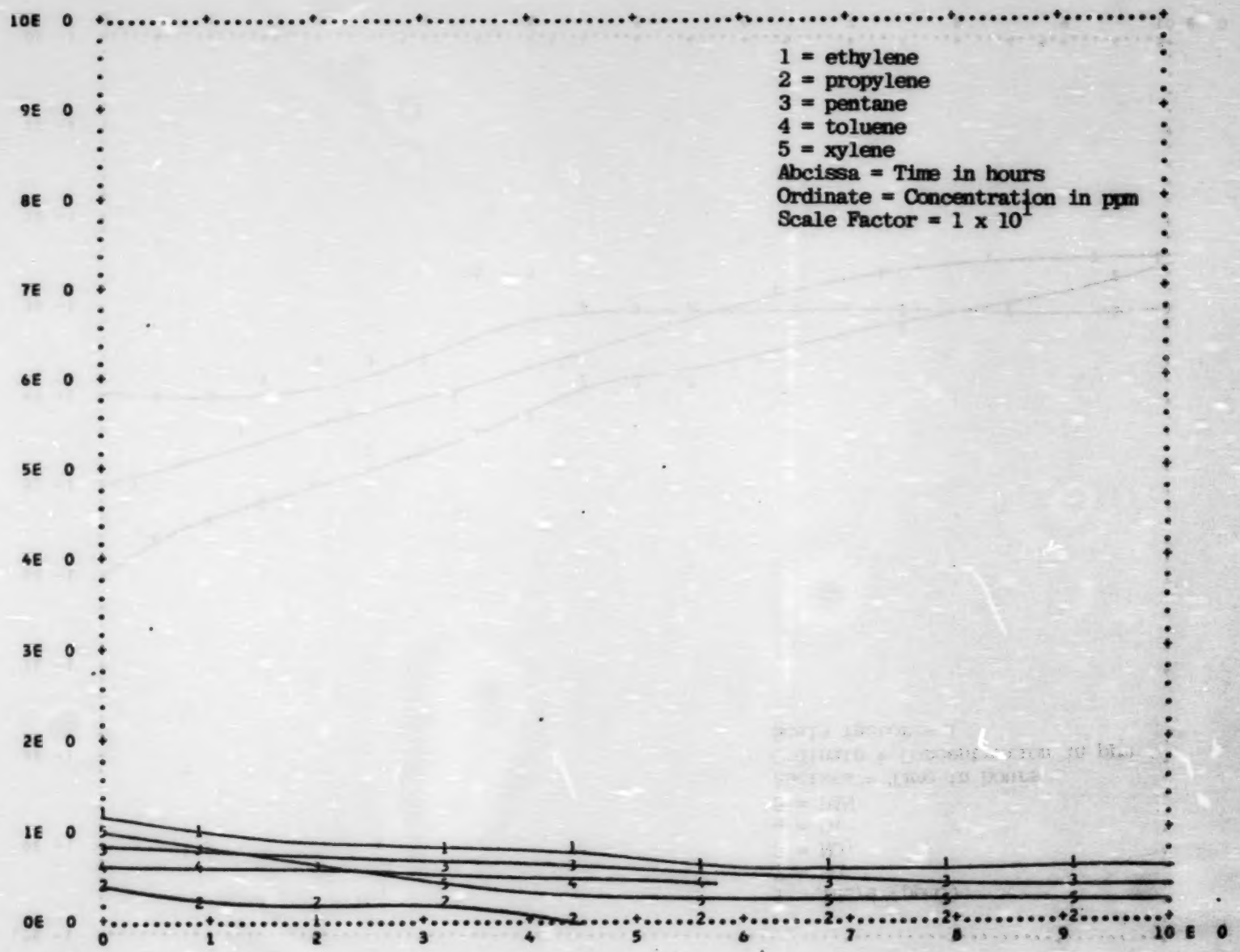
Initial Oxidant by Neutral Buffered KI = <0.01 ppm

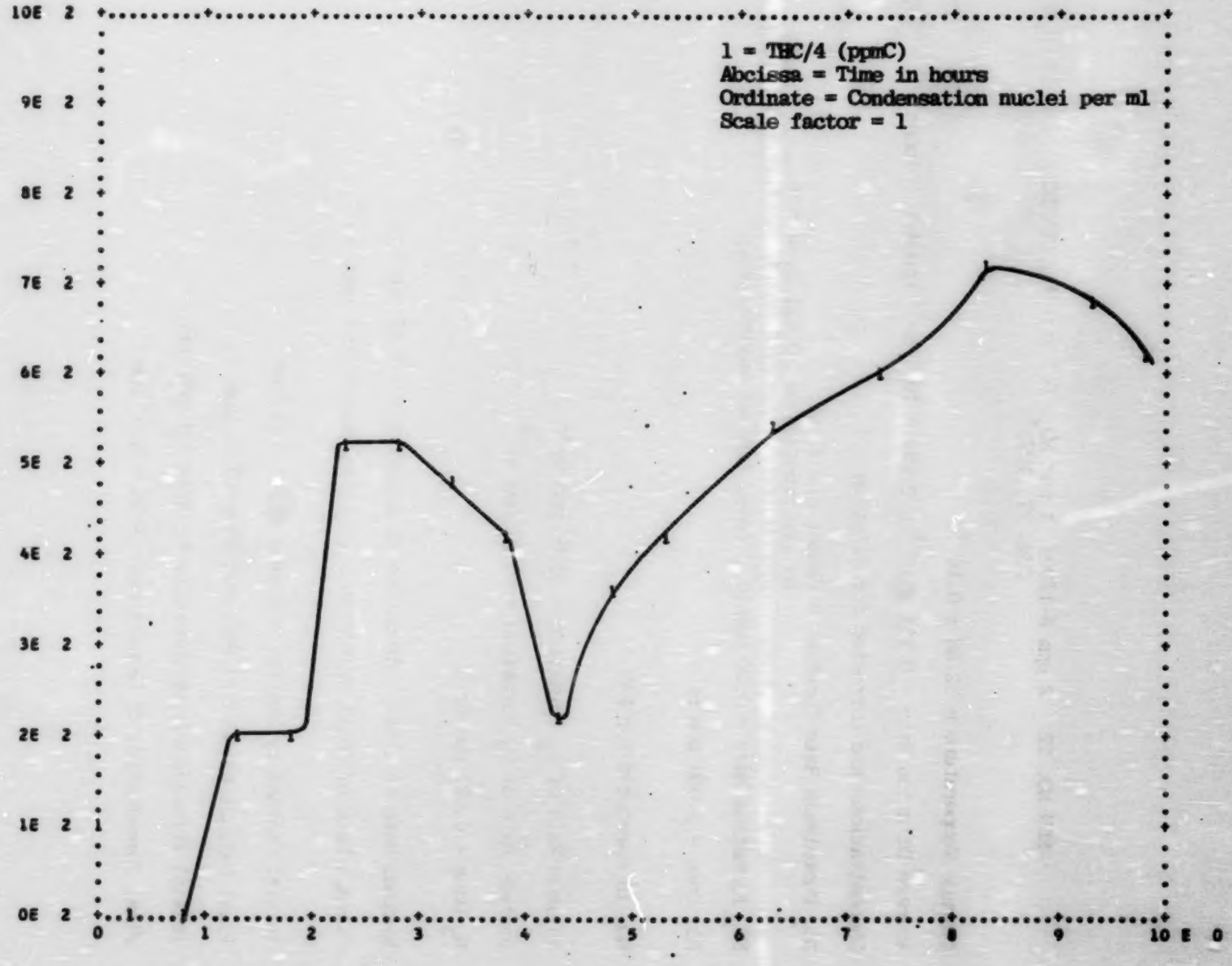
Final Oxidant by Neutral Buffered KI = <0.01 ppm

Initial Formaldehyde by Chromatropic Acid = 0 ppm

Final Formaldehyde by Chromatropic Acid = 0.09 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = ethylene
2 = propylene
3 = pentane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale Factor = 1 x 10^1
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 1
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0 1 2 3 4 5 6 7 8 9 10 E 0

RUN NO. 22: 2 ppm A-11004, 1 ppm NO_x, 0.3 ppm NO_2, STATIC
JUNE 27, 1975

Average Temperature = 32.86 ± 0.19 °C

Average Dilution Rate = $0.141 \times 10^{-1} \pm 0.983 \times 10^{-3}$ hr^{-1} chamber volumes

Concentrations are corrected for dilution

NO_2 Photolysis Rate Constant = Cannot calculate.
No intersection of NO and O_3 curves.

NO_2 Formation Rate = 0.20 ppm hr^{-1} (used time at maximum NO_2).

NO_2 Dose = 2.958 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = <0.01 ppm hr^{-1}

Average Rate of O_3 Formation = <0.01 ppm hr^{-1}

O_3 Dose = 0.025 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.17 ppmC hr^{-1}

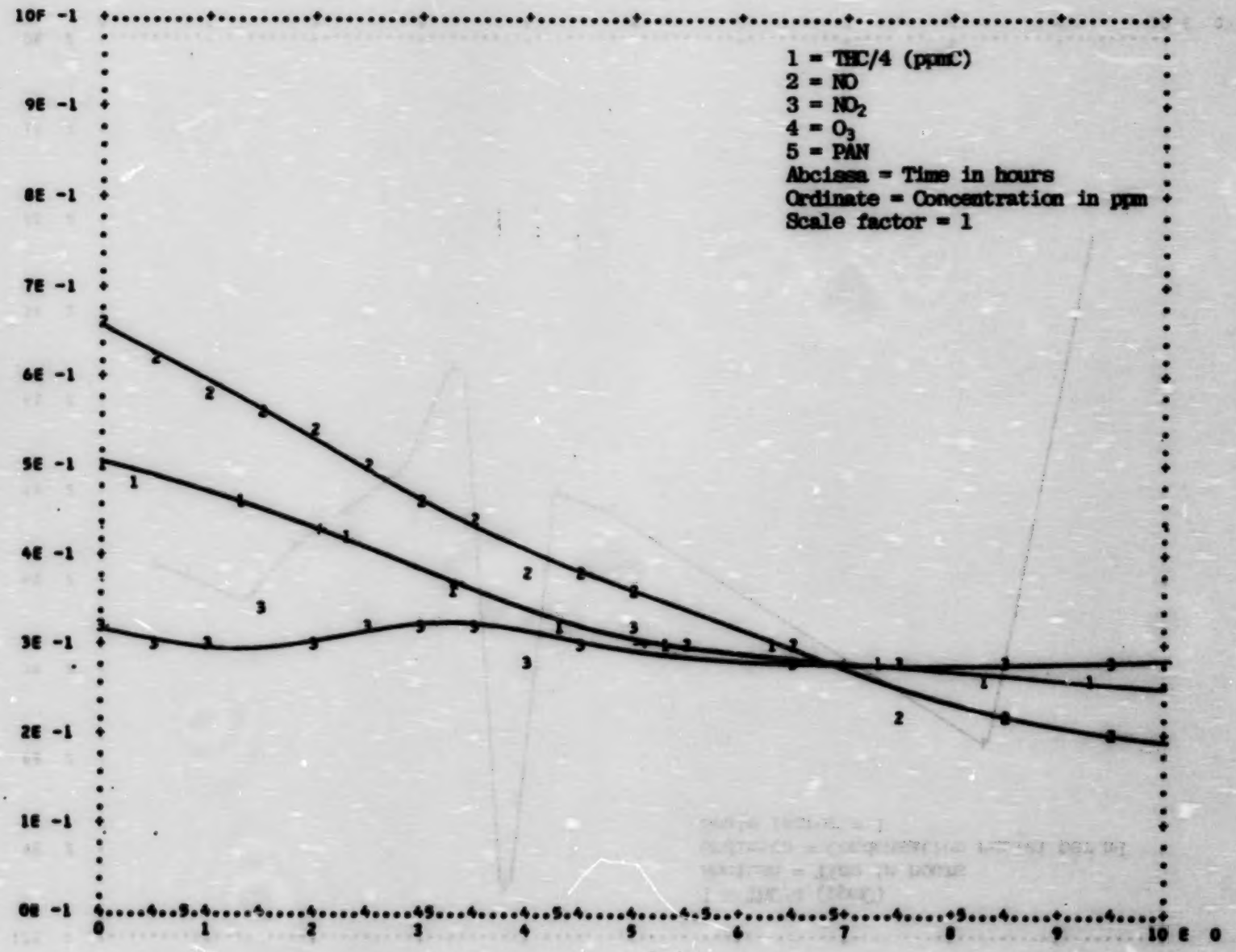
Average Rate of Total Hydrocarbon Disappearance = 0.16 ppmC hr^{-1}

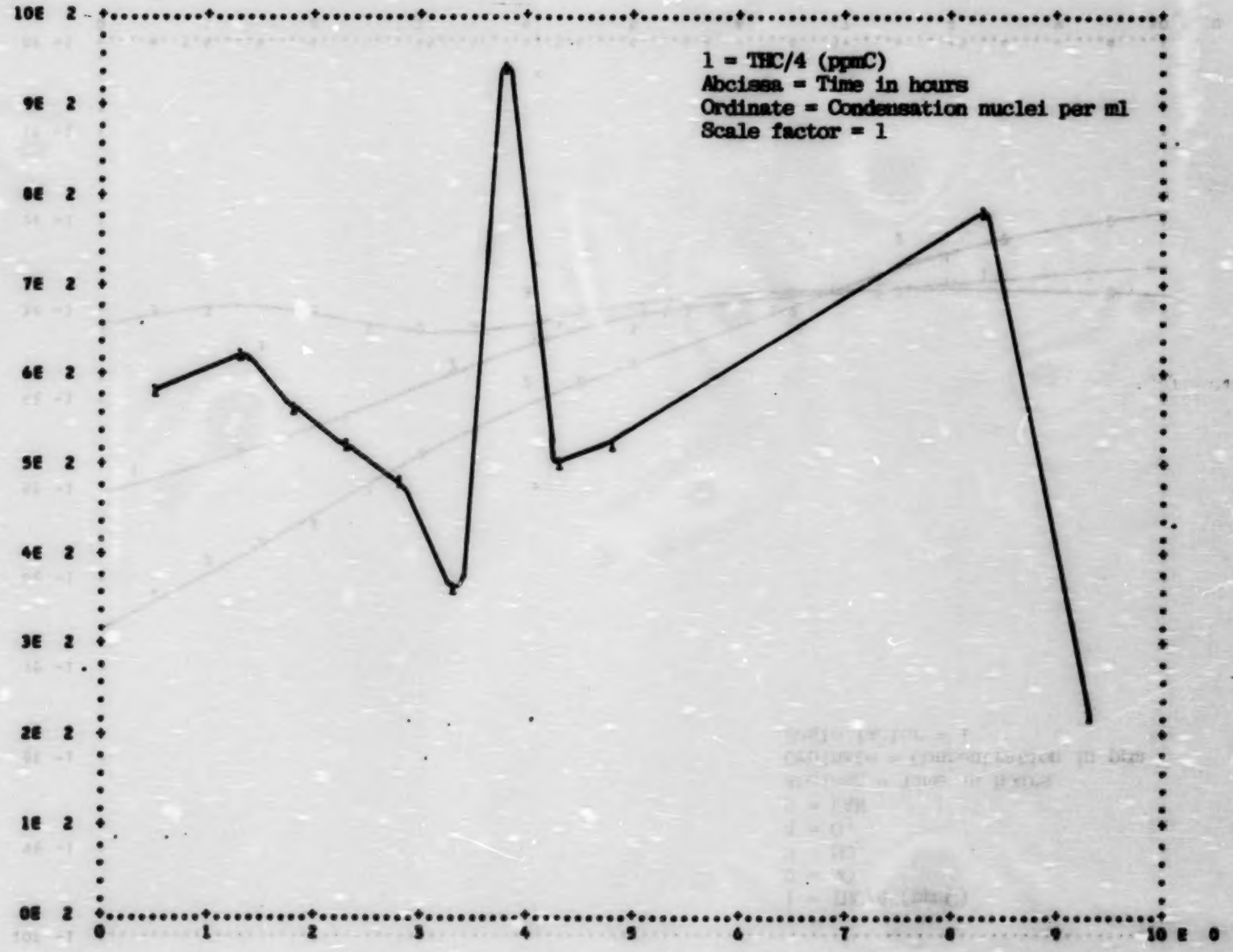
Initial Oxidant by Neutral Buffered KI = <0.01 ppm

Final Oxidant by Neutral Buffered KI = <0.01 ppm

Initial Formaldehyde by Chromatropic Acid = <0.01 ppm

Final Formaldehyde by Chromatropic Acid = 0.06 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0
1
2
3
4
5
6
7
8
9
10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 1
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0
1
2
3
4
5
6
7
8
9
10 E 0

RUN NO. 21: 2 ppm A-11004, 1 ppm NO_x, 0.3 ppm NO_2, STATIC
JUNE 25, 1975

Average Temperature = 32.81 ± 0.18 °C

Average Dilution Rate = $0.130 \times 10^{-1} \pm 0.876 \times 10^{-3}$ hr^{-1} chamber volumes

Concentrations are corrected for dilution

NO_2 Photolysis Rate Constant = Cannot calculate.
No intersection of NO and O_3 curves.

NO_2 Formation Rate = 0.35 ppm hr^{-1} (used time at maximum NO_2).

NO_2 Dose = 2.895 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = O_3 formation nil

Average Rate of O_3 Formation = O_3 formation nil

O_3 Dose = 0.012 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.10 ppmC hr^{-1}

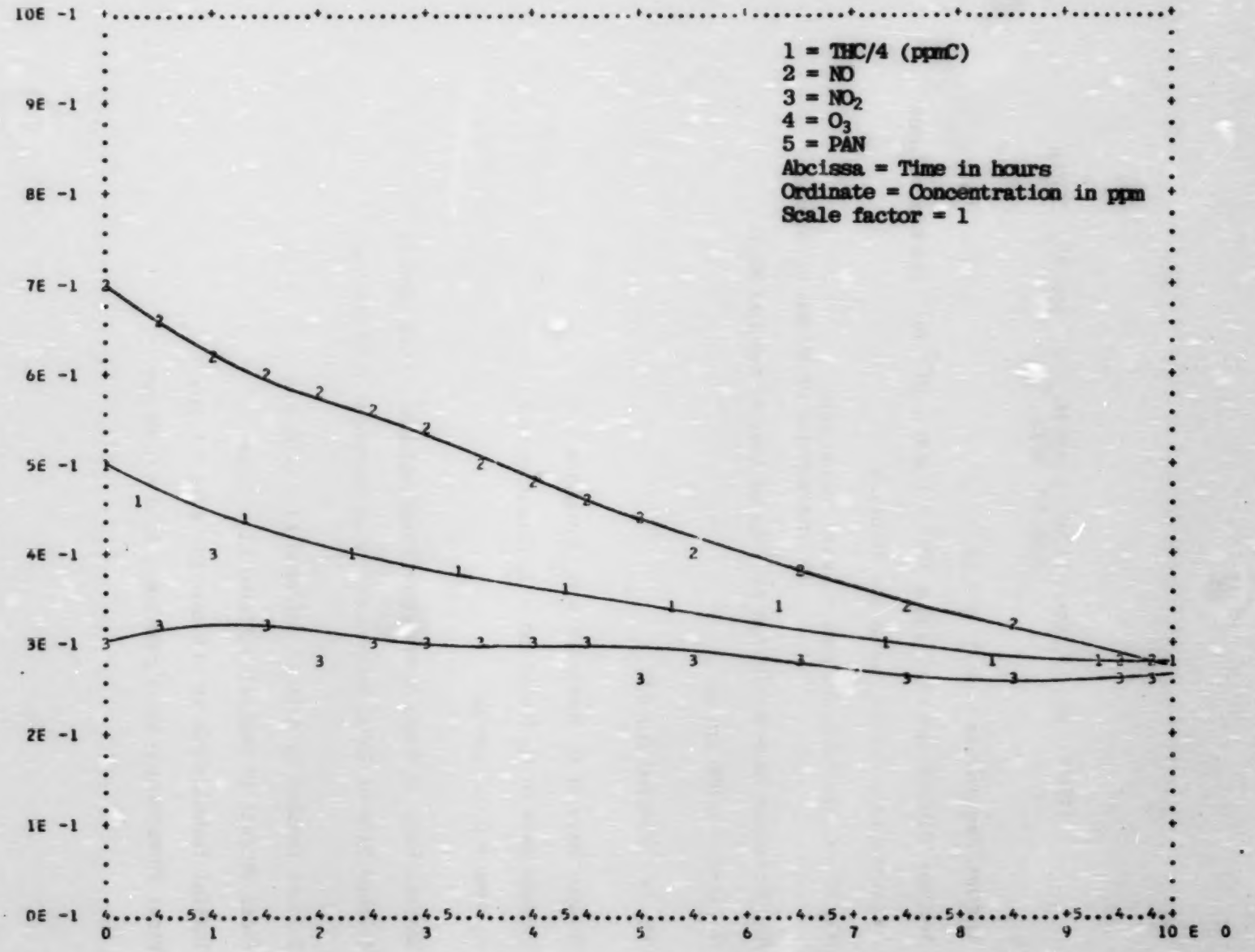
Average Rate of Total Hydrocarbon Disappearance= 0.15 ppmC hr^{-1}

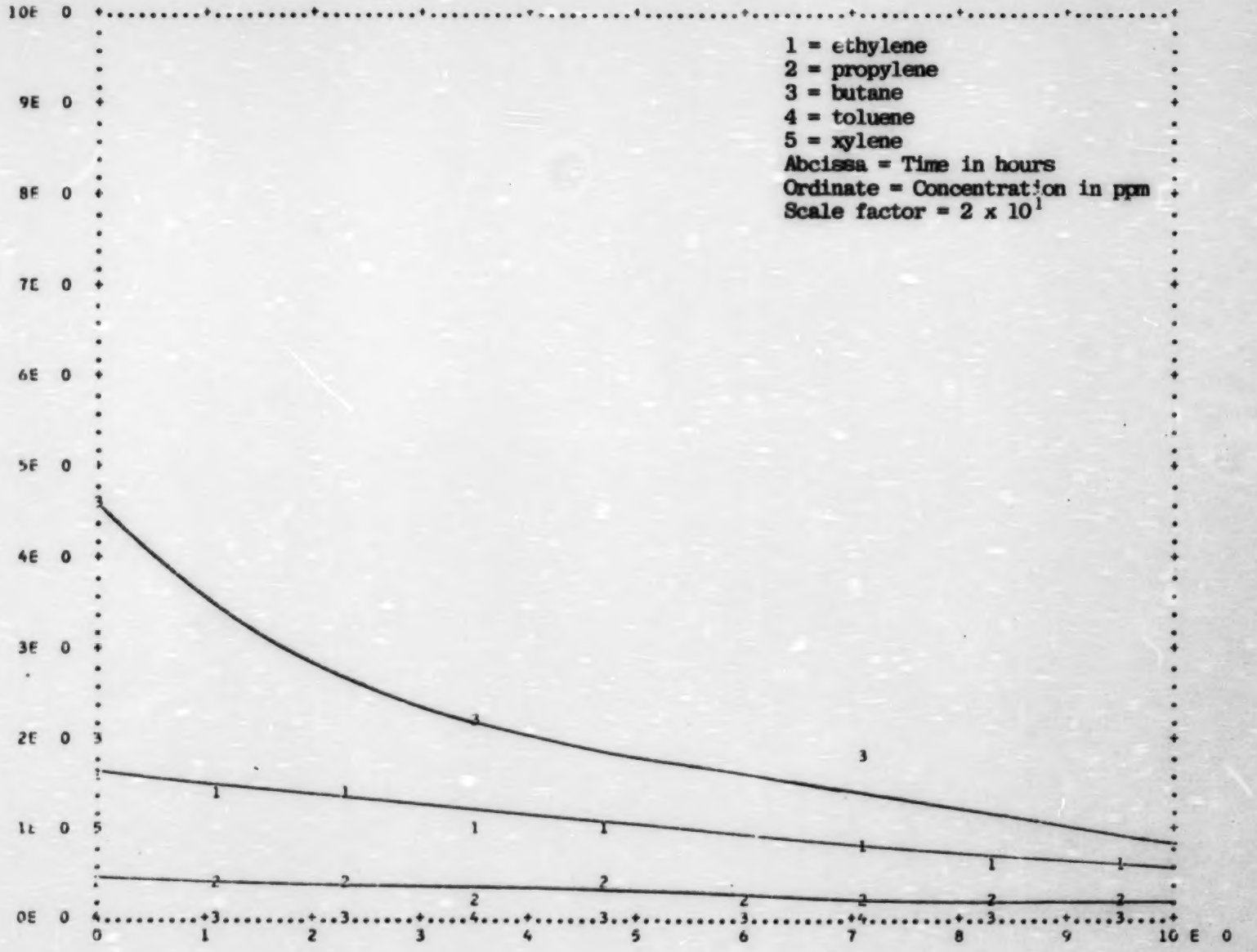
Initial Oxidant by Neutral Buffered KI = 0.01 ppm

Final Oxidant by Neutral Buffered KI = 0 ppm

Initial Formaldehyde by Chromatropic Acid = 0 ppm

Final Formaldehyde by Chromatropic Acid = 0.29 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0
1
2
3
4
5
6
7
8
9
10 E 0


1 = ethylene
2 = propylene
3 = butane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10[1]
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0

APPENDIX C

CALCULATED PARAMETERS AND GRAPHS
UNANALYZED RUNS

XL-228 (Non-catalyst blend)

and

A-11004 (Catalyst blend)

at

4 ppmC, $HC/NO_x = 4$, $HC/NO_x = 8$

static, dilution, and dynamic conditions

Note: The E field specification (floating point) notation was used for the ordinate and abcissa values on the graphs in this appendix. Explanation of notation:

OE -1 = 0×10^{-1}
CE 1 = 0×10^{1}

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RUN NO. 5R: 4 ppm XL-228, 1 ppm NO_x, STATIC
MAY 7, 1975

Average Temperature = 32.65 ± 0.06 °C

Average Dilution Rate = $0.170 \times 10^{-1} \pm 0.707 \times 10^{-3}$ hr^{-1} chamber volumes

Concentrations are corrected for dilution

NO_2 Photolysis Rate Constant = 0.69 min^{-1}

NO_2 Formation Rate = 0.15 ppm hr^{-1}

NO_2 Dose = 3.287 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.05 ppm hr^{-1}

Average Rate of O_3 Formation = 0.03 ppm hr^{-1}

O_3 Dose = 1.365 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.33 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 0.42 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = <.01 ppm

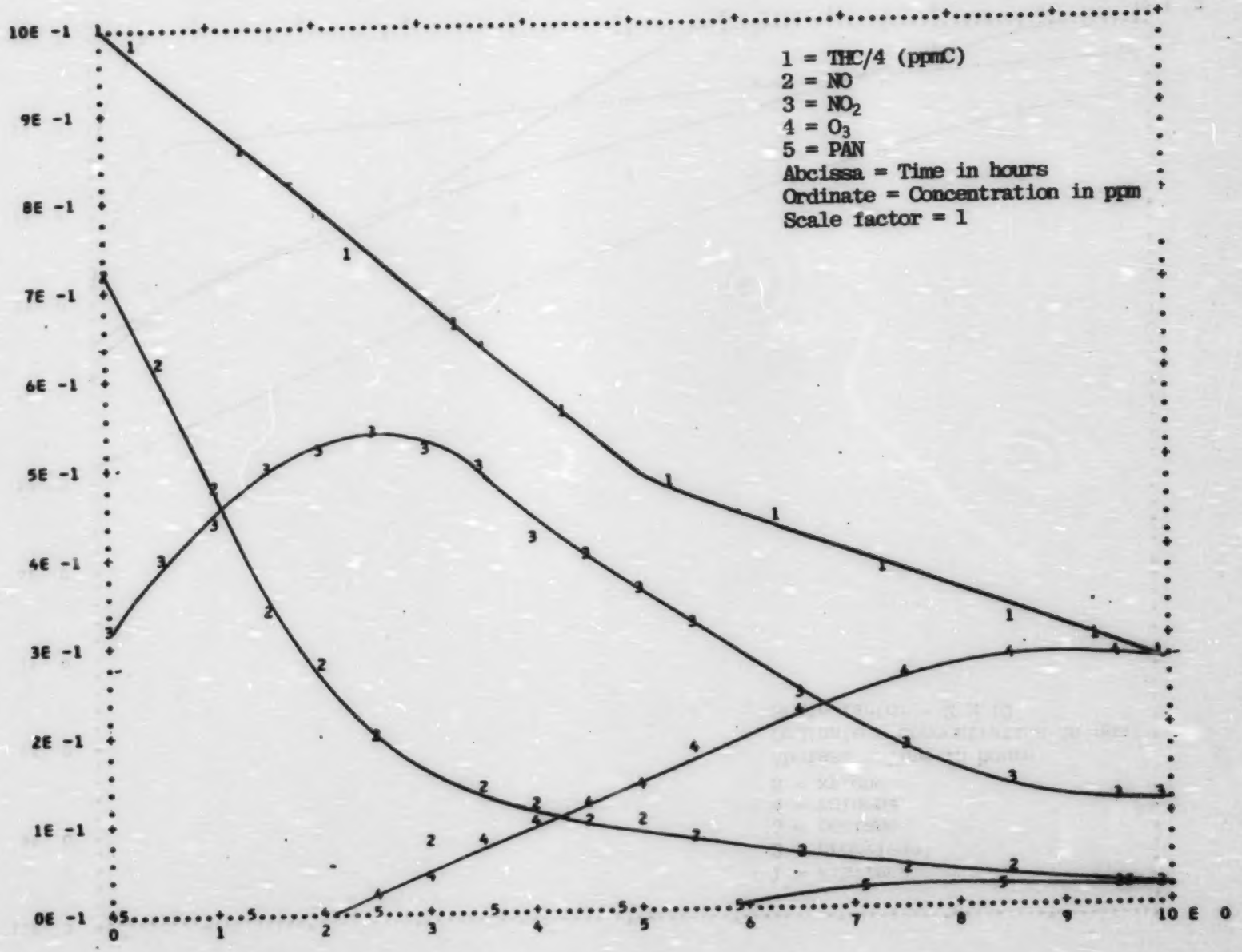
Final Oxidant by Neutral Buffered KI = 0.25 ppm

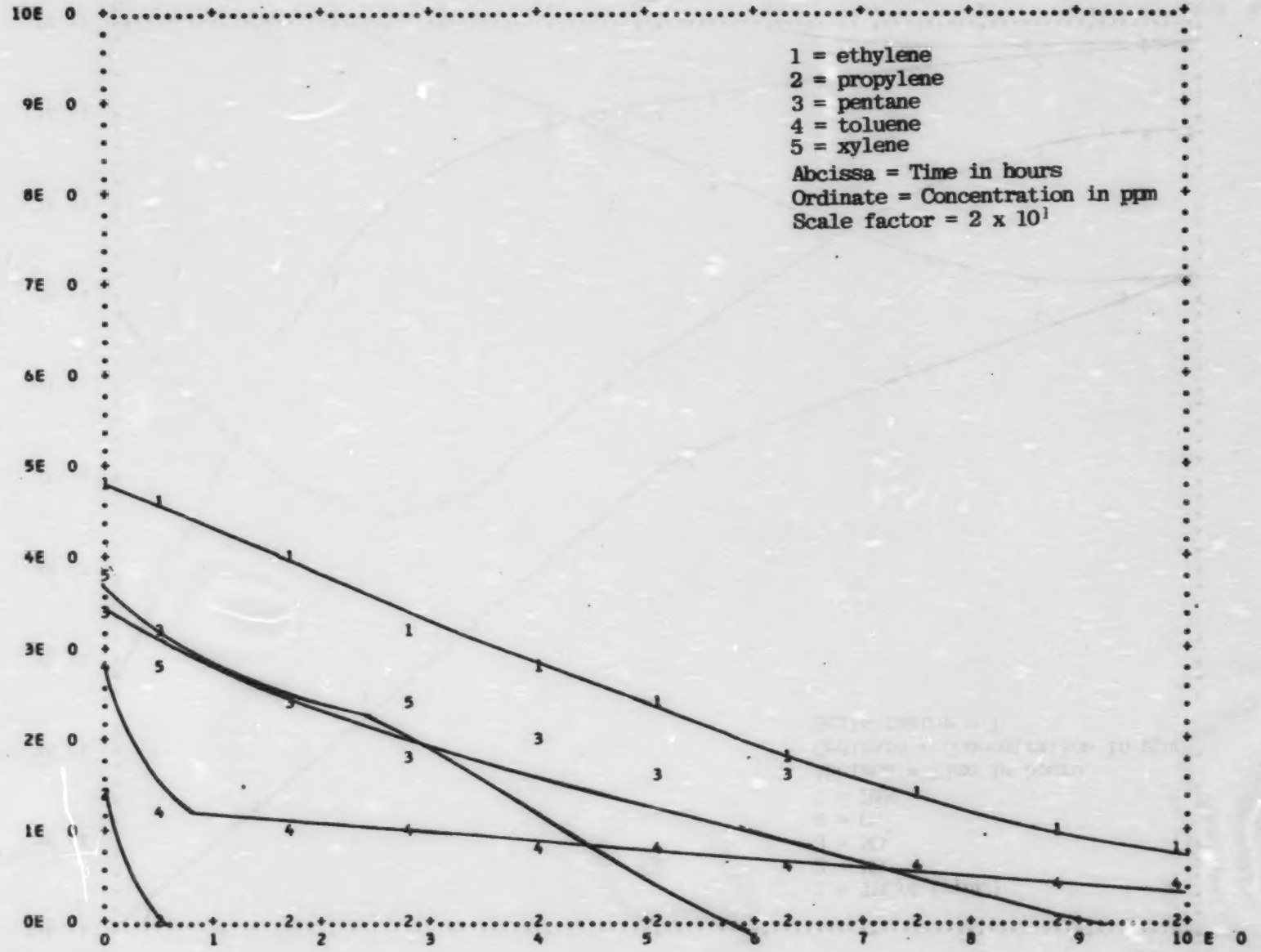
Initial Formaldehyde by Chromatropic Acid = 0 ppm

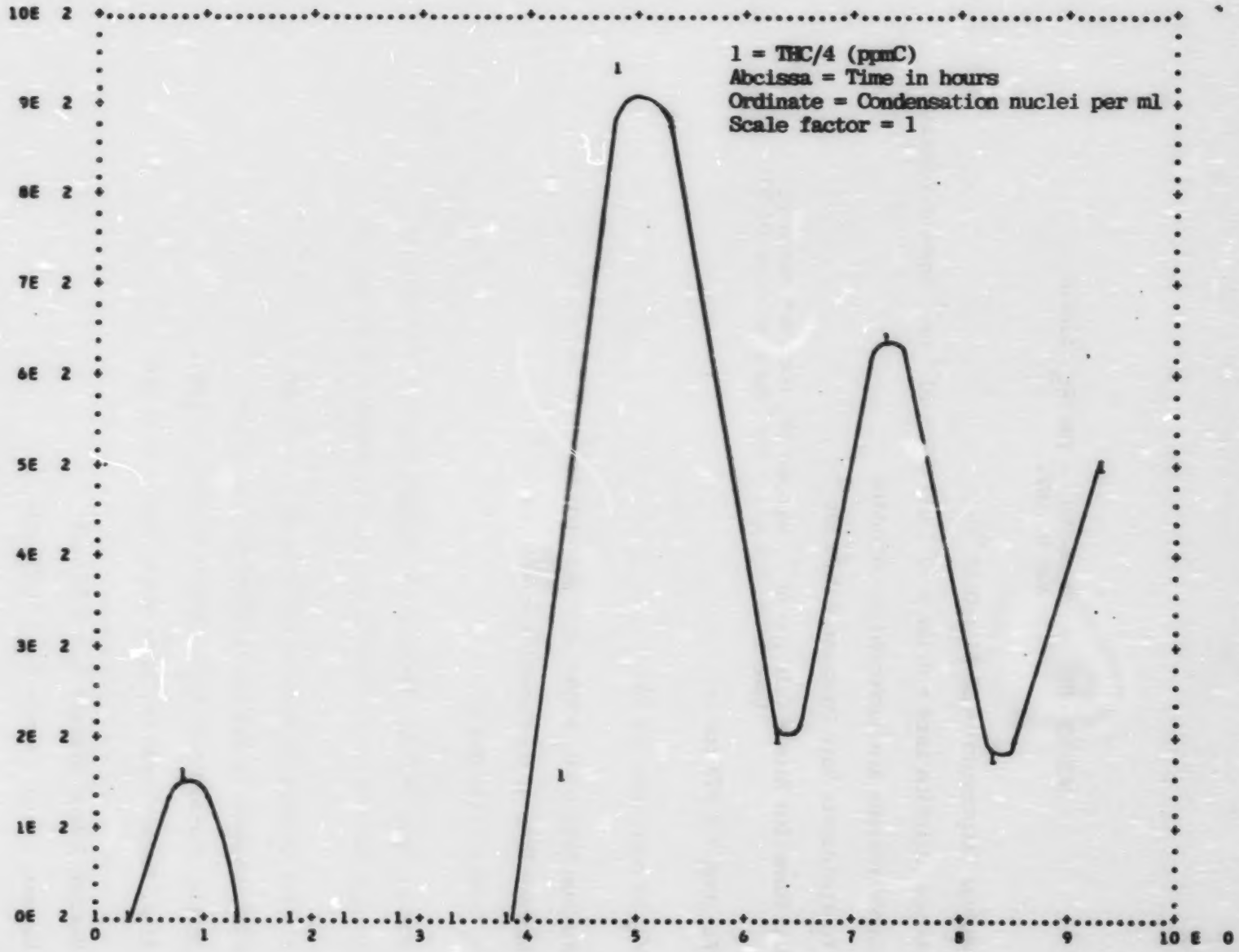
Final Formaldehyde by Chromatropic Acid = 0.18 ppm

Maximum 1-hour Average O_3 = 0.283 ppm

Maximum 1-hour Average NO_2 = 0.434 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0
1
2
3
4
5
6
7
8
9
10 E 0


1 = ethylene
2 = propylene
3 = pentane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10¹
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 1
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0
1
2
3
4
5
6
7
8
9
10 E 0

RUN NO. 7R: 4 ppm XL-228, 1 ppm NO_x, STATIC
MAY 9, 1975

Average Temperature = 32.81 ± 0.13 °C

Average Dilution Rate = $0.154 \times 10^{-1} \pm 0.668 \times 10^{-3}$ hr^{-1} chamber volumes

Concentrations are corrected for dilution

NO_2 Photolysis Rate Constant = 0.94 min^{-1}

NO_2 Formation Rate = 0.16 ppm hr^{-1}; Maximum NO_2 does not reach $T_{\frac{1}{2}}$. Used time (2.2 hrs.) for Maximum value (0.50).

NO_2 Dose = 2.872 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.06 ppm hr^{-1}

Average Rate of O_3 Formation = 0.04 ppm hr^{-1}

O_3 Dose = 1.733 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.34 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 0.45 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = <.01 ppm

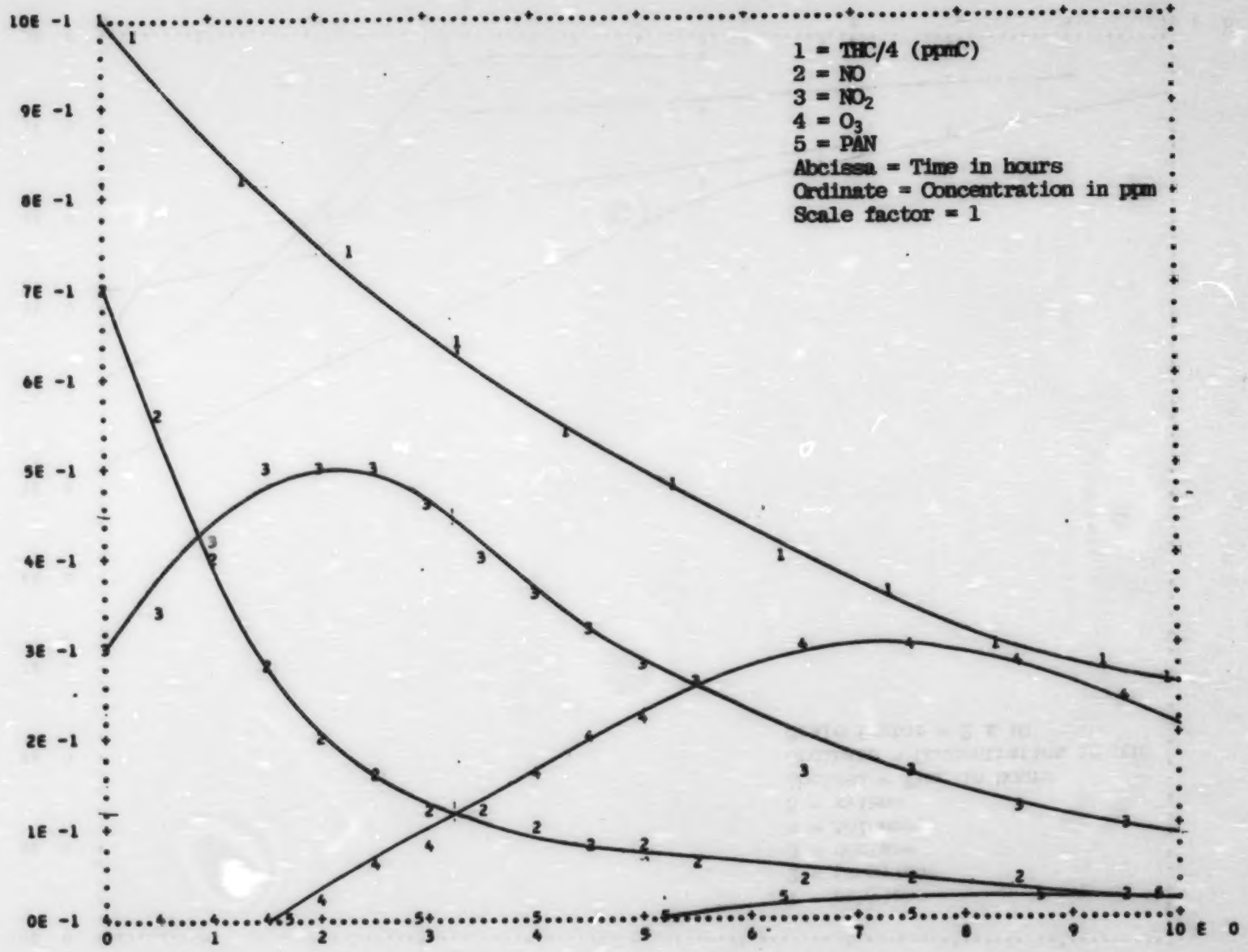
Final Oxidant by Neutral Buffered KI = 0.16 ppm

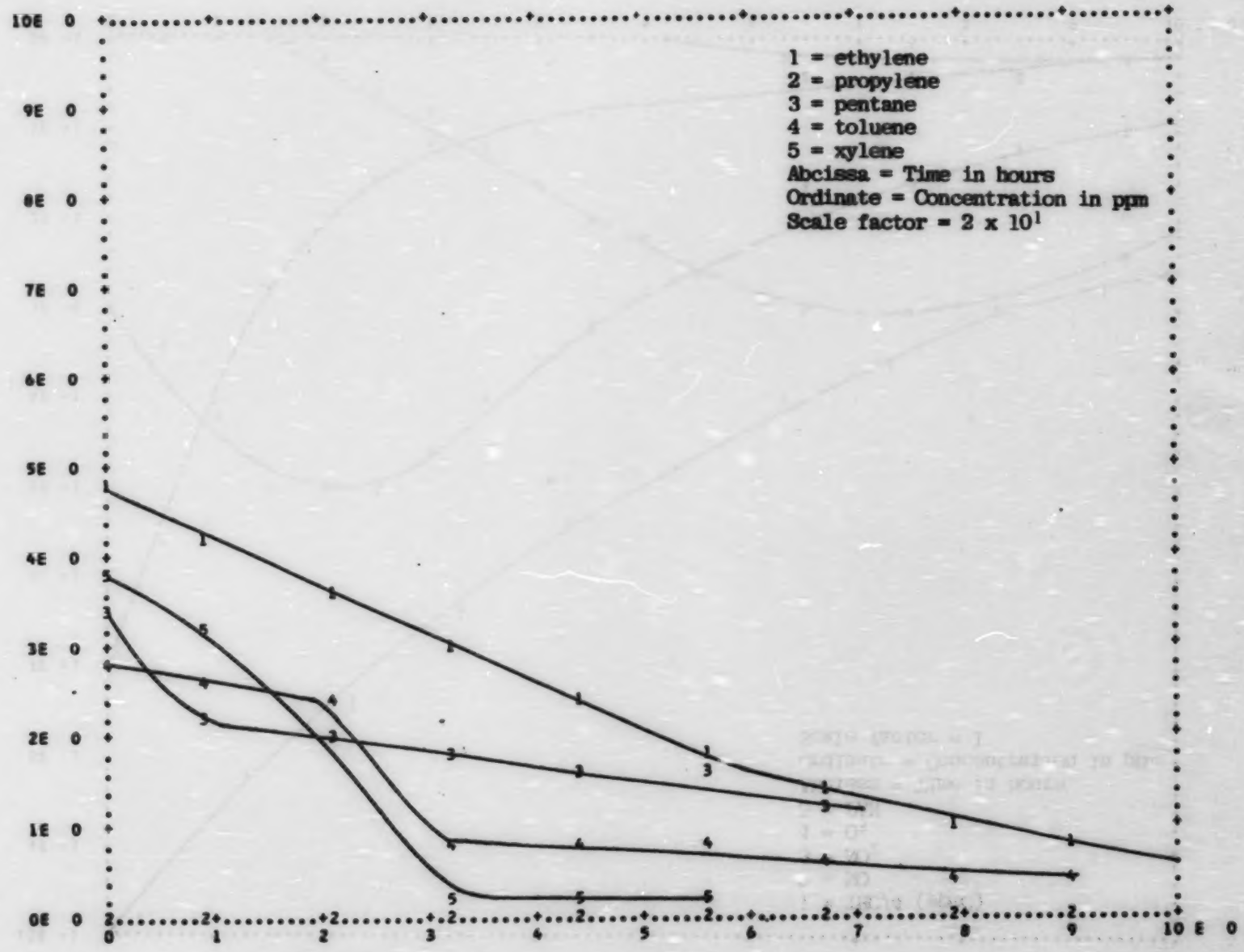
Initial Formaldehyde by Chromatropic Acid = 0 ppm

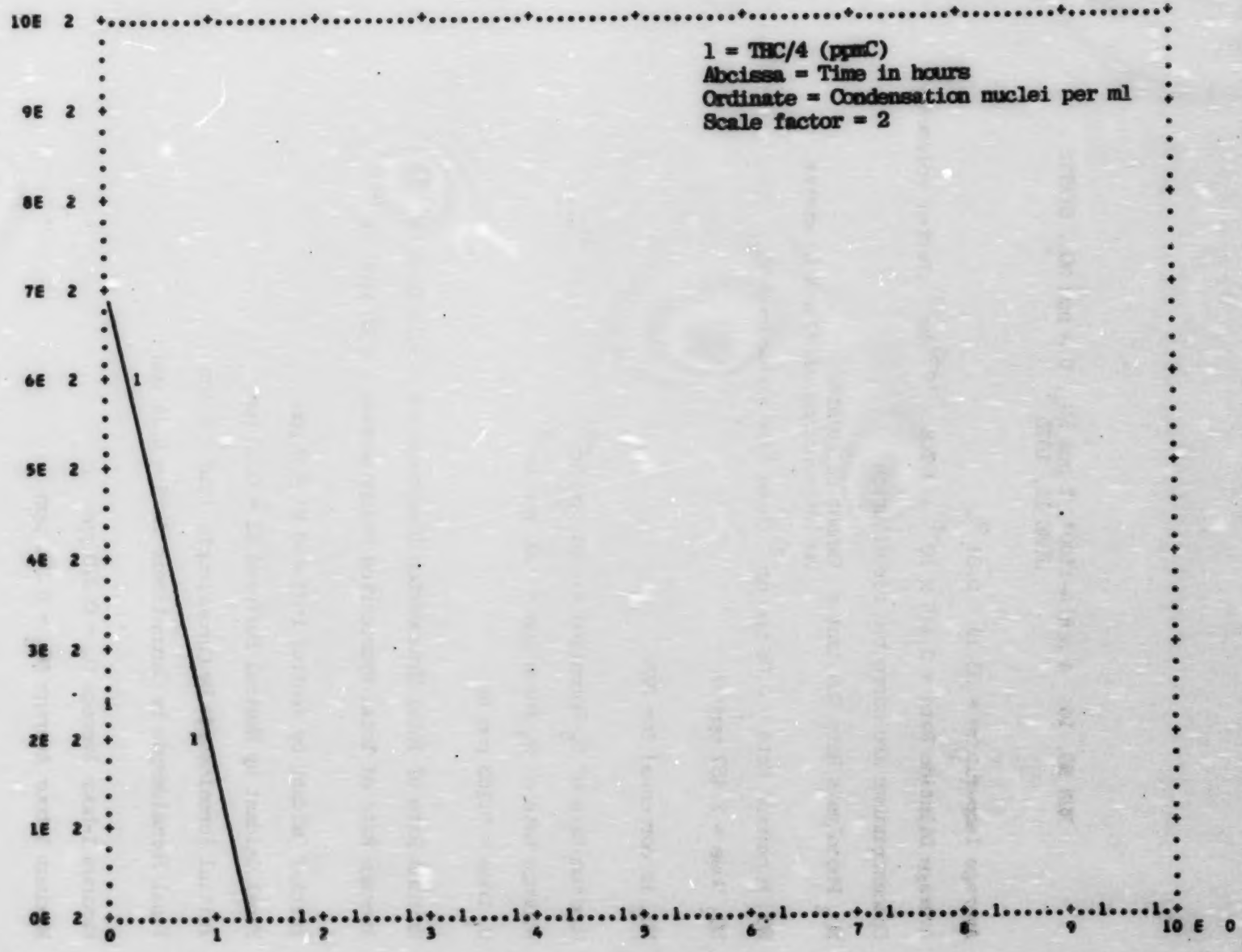
final Formaldehyde by Chromatropic Acid = 0.17 ppm

Maximum 1-hour Average O_3 = 0.297 ppm

Maximum 1-hour Average NO_2 = 0.493 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = ethylene
2 = propylene
3 = pentane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10¹
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 2
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0
1
2
3
4
5
6
7
8
9
10 E 0

RUN NO. 16: 4 ppm A-11004, 1 ppm NO_x, 0.3 ppm NO_2, STATIC
JUNE 11, 1975

Average Temperature = 33.18 ± 0.04 °C

Average Dilution Rate = $0.145 \times 10^{-1} \pm 0.748 \times 10^{-3}$ hr^{-1} chamber volumes

Concentrations are corrected for dilution

NO_2 Photolysis Rate Constant = Cannot calculate.
No intersection of NO and O_3 curves.

NO_2 Formation Rate = 0.08 ppm hr^{-1} (used time at maximum NO_2).

NO_2 Dose = 3.457 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = <.01 ppm hr^{-1}

Average Rate of O_3 Formation = <.01 ppm hr^{-1}

O_3 Dose = 0.163 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.22 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 0.30 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = 0 ppm

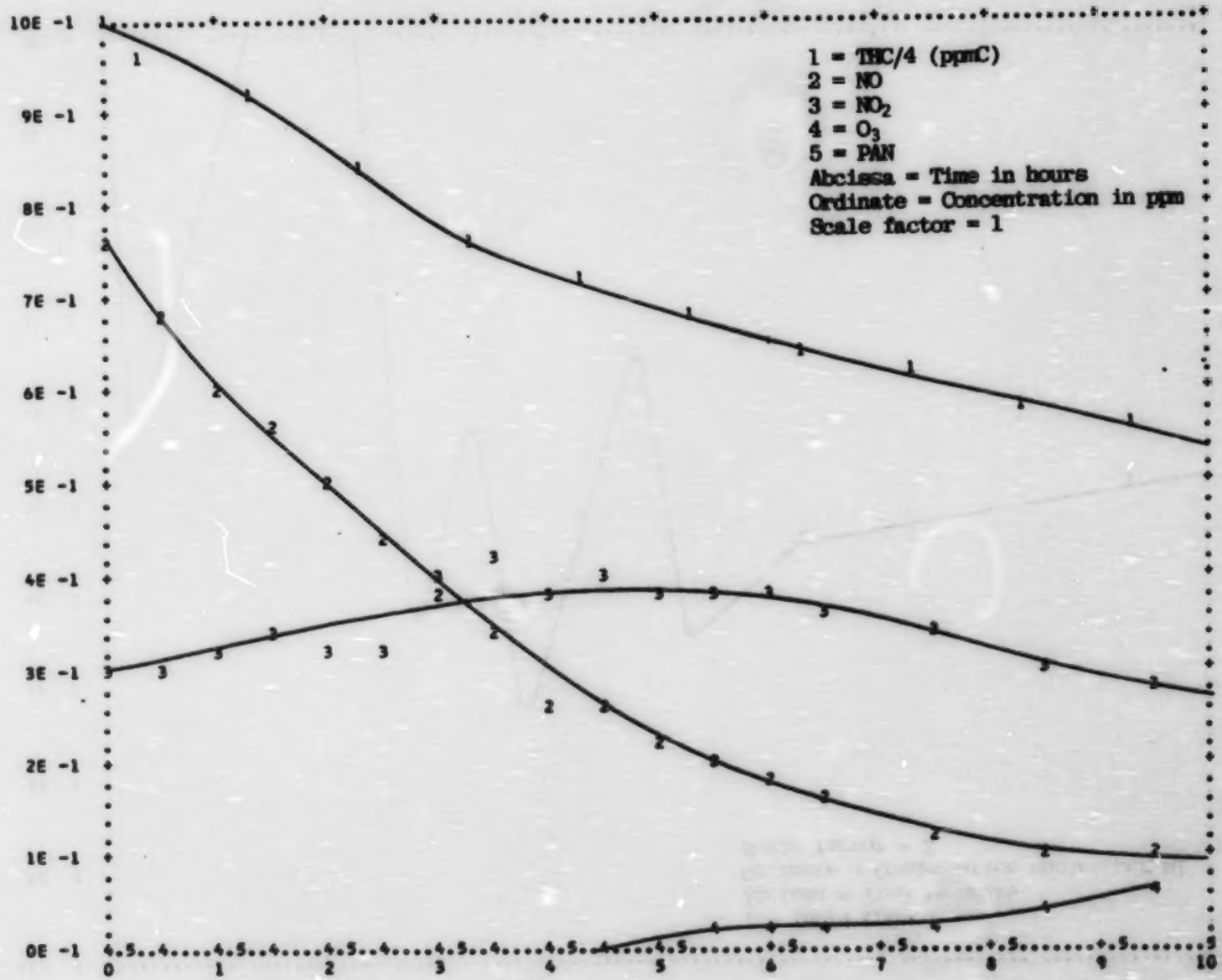
Final Oxidant by Neutral Buffered KI = 0.03 ppm

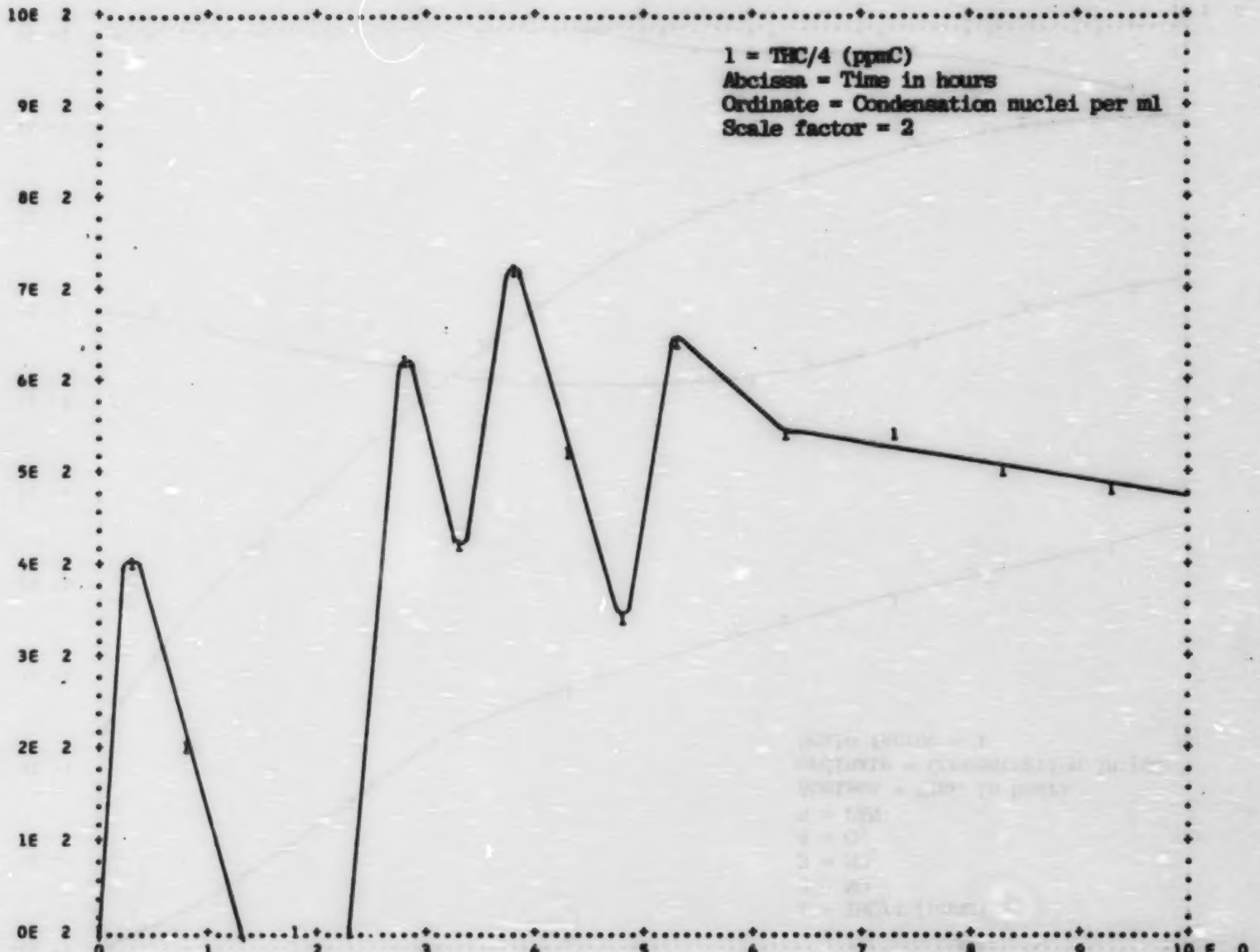
Initial Formaldehyde by Chromatropic Acid = 0 ppm

Final Formaldehyde by Chromatropic Acid = 0.14 ppm

Maximum 1-hour Average O_3 = 0.070 ppm

Maximum 1-hour Average NO_2 = 0.385 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 2
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0 1 2 3 4 5 6 7 8 9 10 E 0

RUN NO. 28: 4 ppm A-11004, 1 ppm NO_x, 0.3 ppm NO_2, STATIC
JULY 16, 1975

Average Temperature = 34.65 ± 0.33 °C

Average Dilution Rate = $0.140 \times 10^{-1} \pm 0.185 \times 10^{-2}$ hr^{-1} chamber volumes

Concentrations are corrected for dilution

NO_2 Photolysis Rate Constant = Cannot calculate.
No intersection of NO and O_3 curves.

NO_2 Formation Rate = 0.59 ppm hr^{-1} (used time at maximum NO_2).

NO_2 Dose = 3.271 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0 ppm hr^{-1}

Average Rate of O_3 Formation = 0 ppm hr^{-1}

O_3 Dose = 0.000 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.28 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 0.21 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = <0.01 ppm

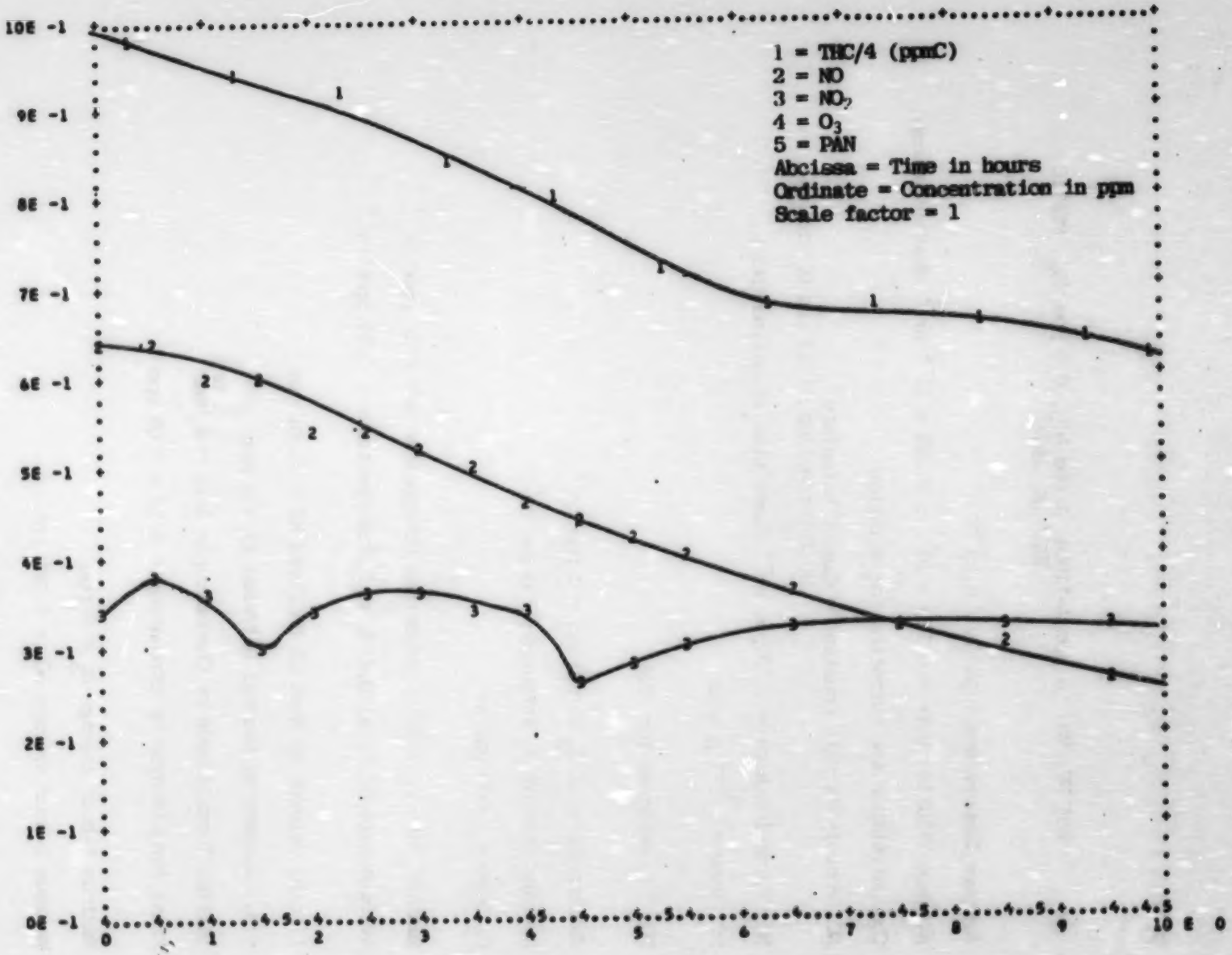
Final Oxidant by Neutral Buffered KI = 0 ppm

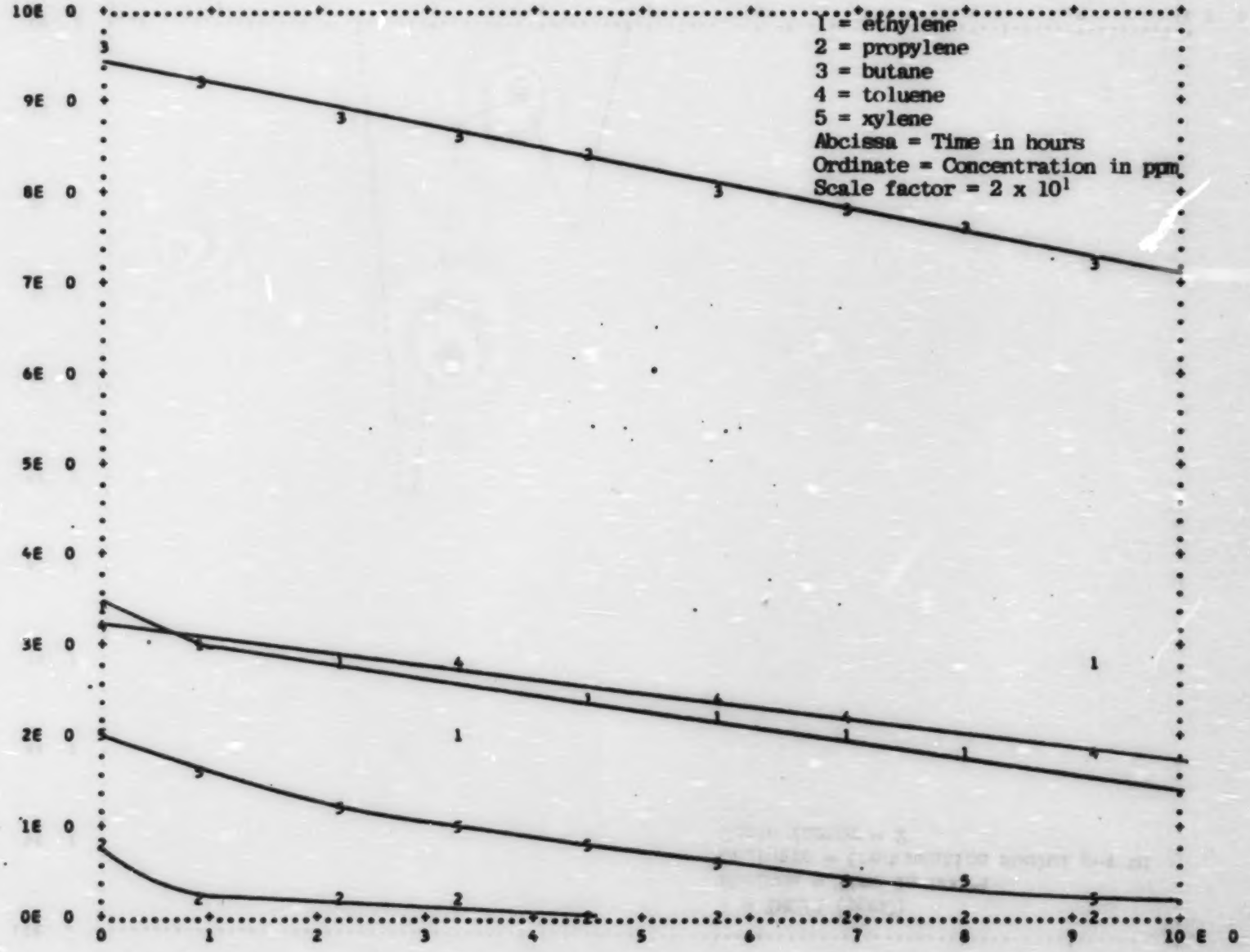
Initial Formaldehyde by Chromatropic Acid = 0 ppm

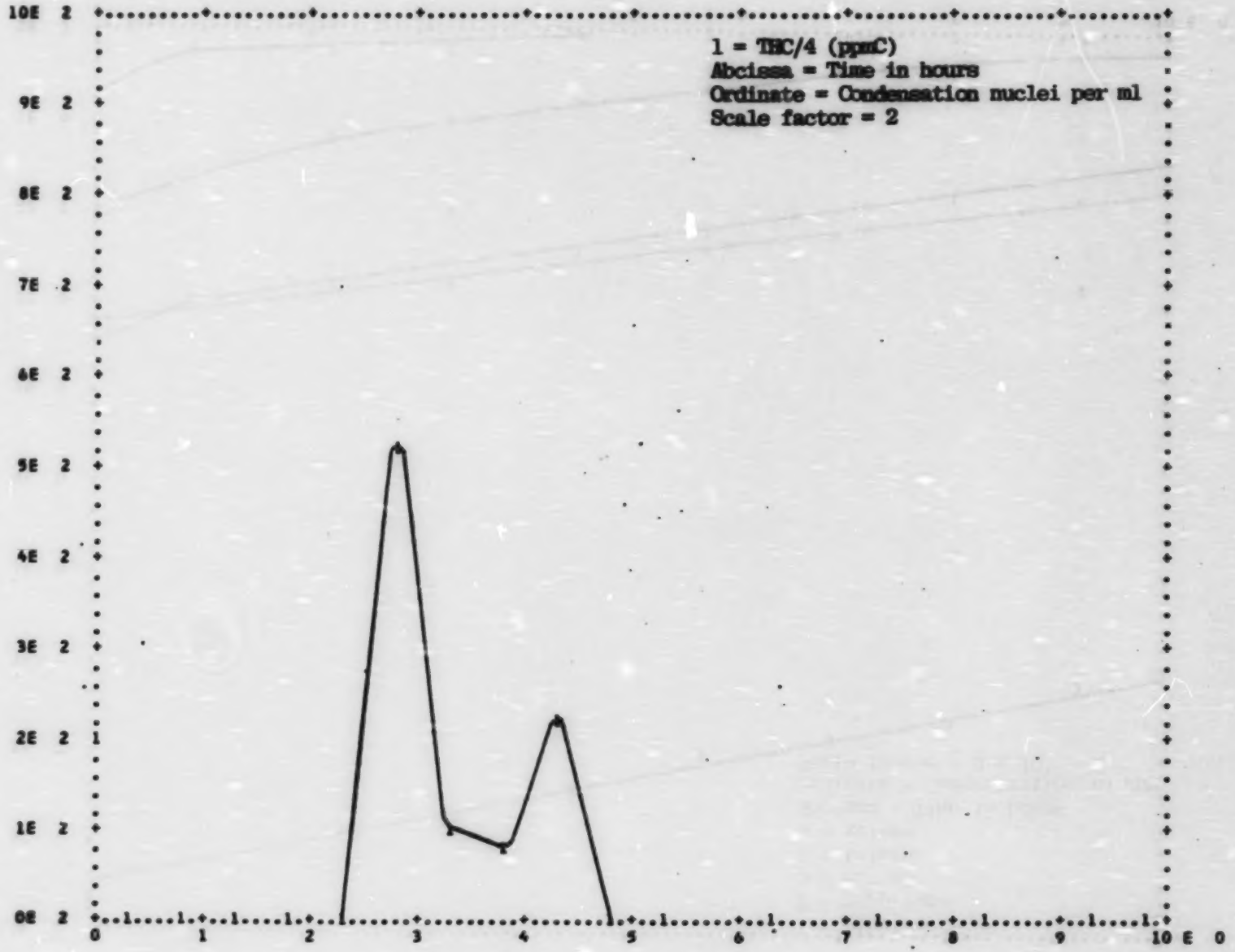
Final Formaldehyde by Chromatropic Acid = 0.08 ppm

Maximum 1-hour Average O_3 = 0 ppm

Maximum 1-hour Average NO_2 = 0.362 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = ethylene
2 = propylene
3 = butane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10¹
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 2
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0 1 2 3 4 5 6 7 8 9 10 E 0

RUN NO. 9R: 4 ppm XL-228, 1 ppm NO_x, DILUTION
MAY 21, 1975

Average Temperature = 32.61 ± 0.03 °C

Average Dilution Rate = $0.532 \times 10^{-1} \pm 0.128 \times 10^{-1}$ hr^{-1} chamber volumes

NO_2 Photolysis Rate Constant = 0.83 min^{-1}

NO_2 Formation Rate = 0.09 ppm hr^{-1} (used maximum value of NO_2 for $T_{\frac{1}{2}}$).

NO_2 Dose = 2.738 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.04 ppm hr^{-1}

Average Rate of O_3 Formation = 0.02 ppm hr^{-1}

O_3 Dose = 0.842 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.37 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 0.46 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = <0.01 ppm

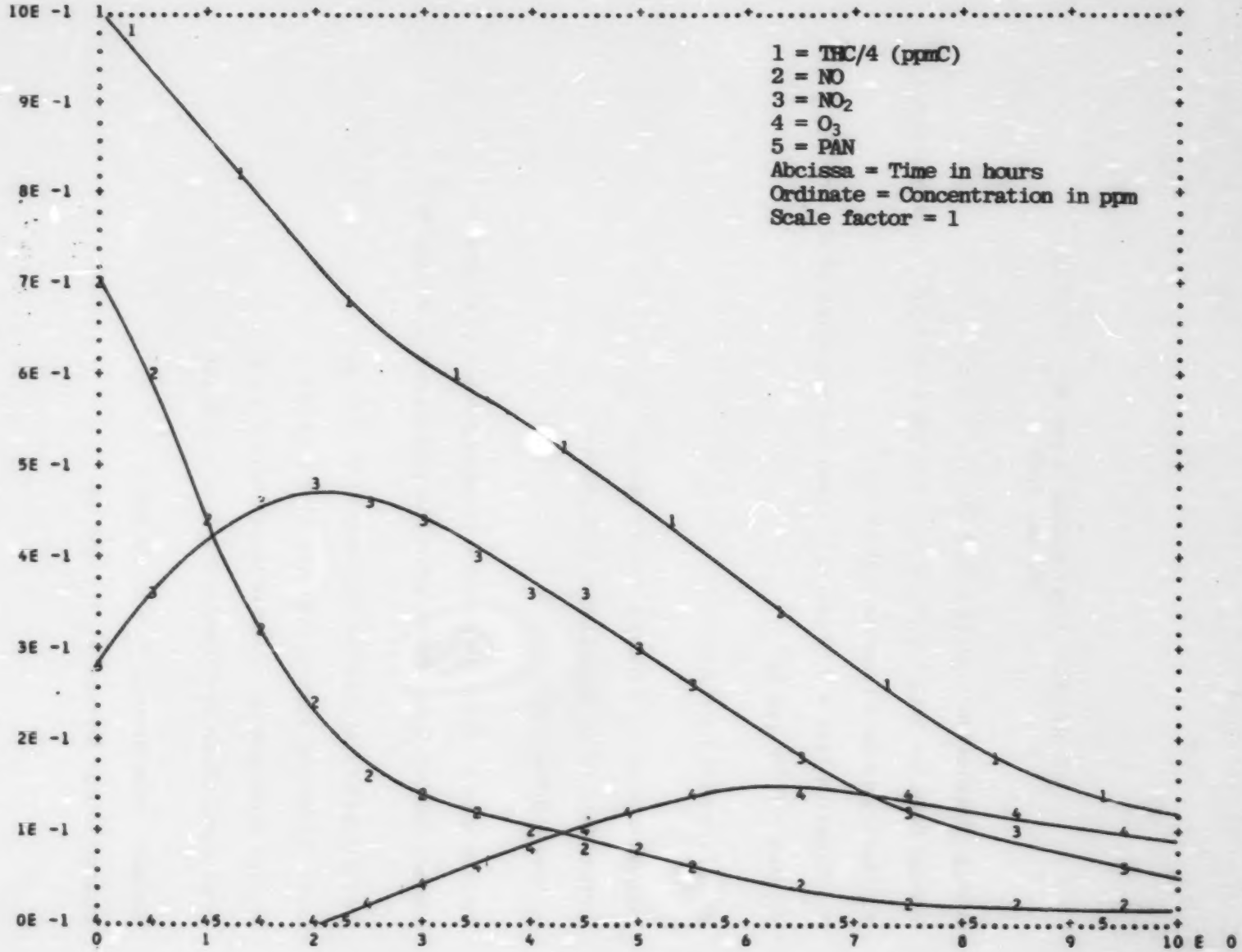
Final Oxidant by Neutral Buffered KI = 0.11 ppm

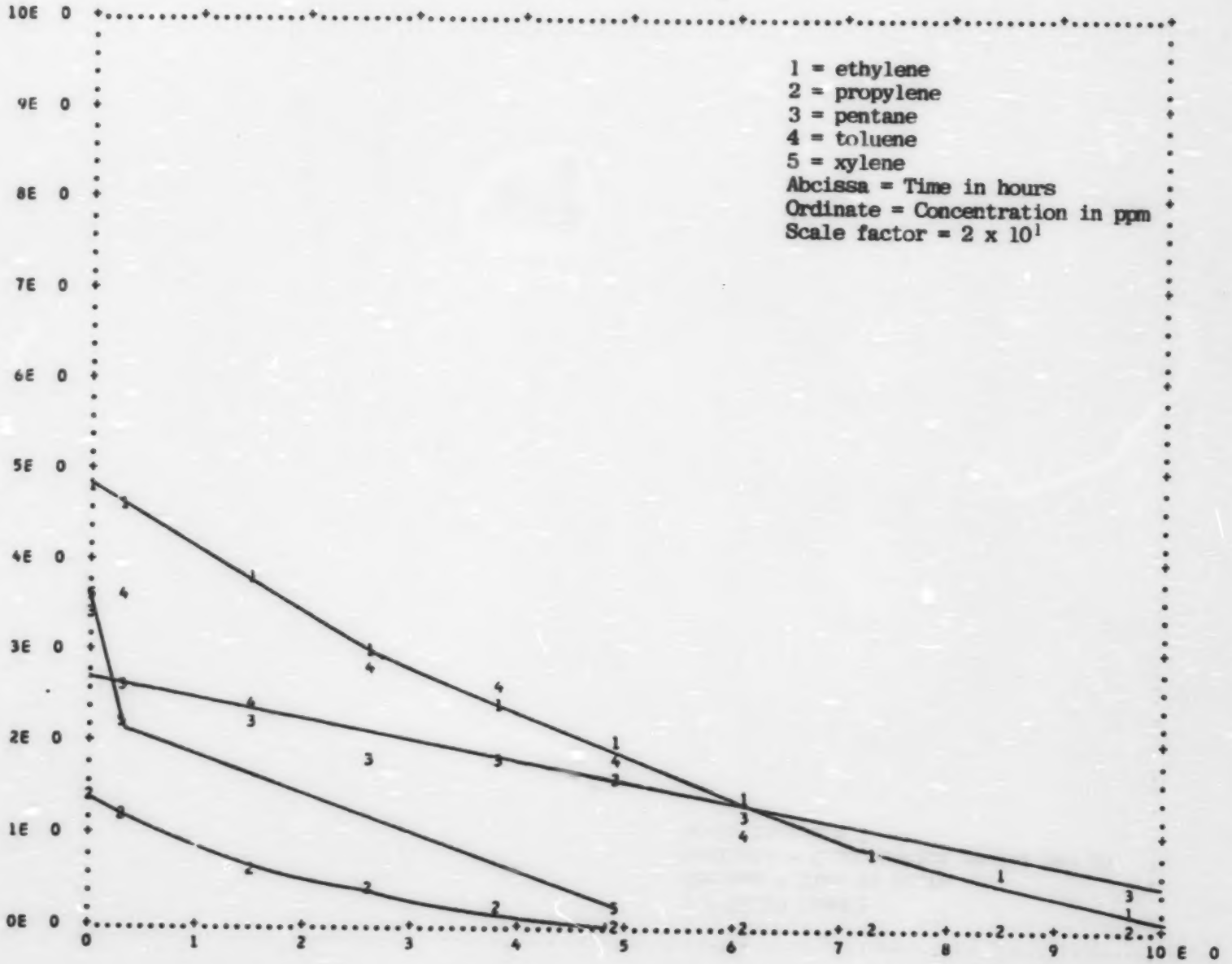
Initial Formaldehyde by Chromatropic Acid = 0 ppm

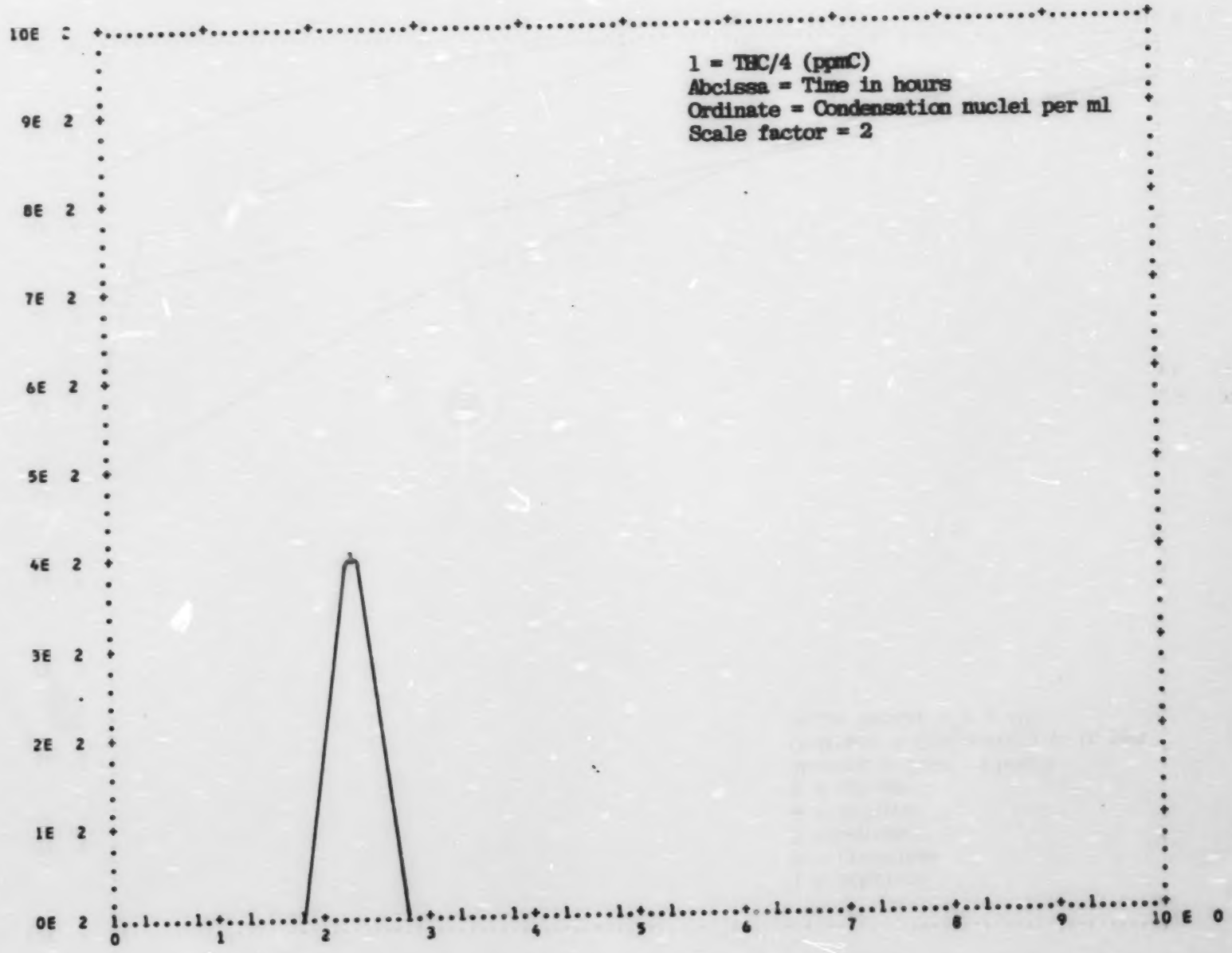
Final Fomaldehyde by Chromatropic Acid = 0.10 ppm

Maximum 1-hour Average O_3 = 0.152 ppm

Maximum 1-hour Average NO_2 = 0.468 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = ethylene
2 = propylene
3 = pentane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10¹
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 2
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0
1
2
3
4
5
6
7
8
9
10 E 0

RUN NO. 18: 4 ppm XL-228, 1 ppm NO_x, 0.3 ppm NO_2, DILUTION
JUNE 16, 1975

Average Temperature = 33.20 ± 0.03 ^{o}C

Average Dilution Rate = $0.539 \times 10^{-1} \pm 0.135 \times 10^{-1}$ hr^{-1} chamber volumes

NO_2 Photolysis Rate Constant = 0.82 min^{-1}

NO_2 Formation Rate = 0.41 ppm hr^{-1}

NO_2 Dose = 2.587 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.04 ppm hr^{-1}

Average Rate of O_3 Formation = 0.03 ppm hr^{-1}

O_3 Dose = 1.047 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.40 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 0.46 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = <0.01 ppm

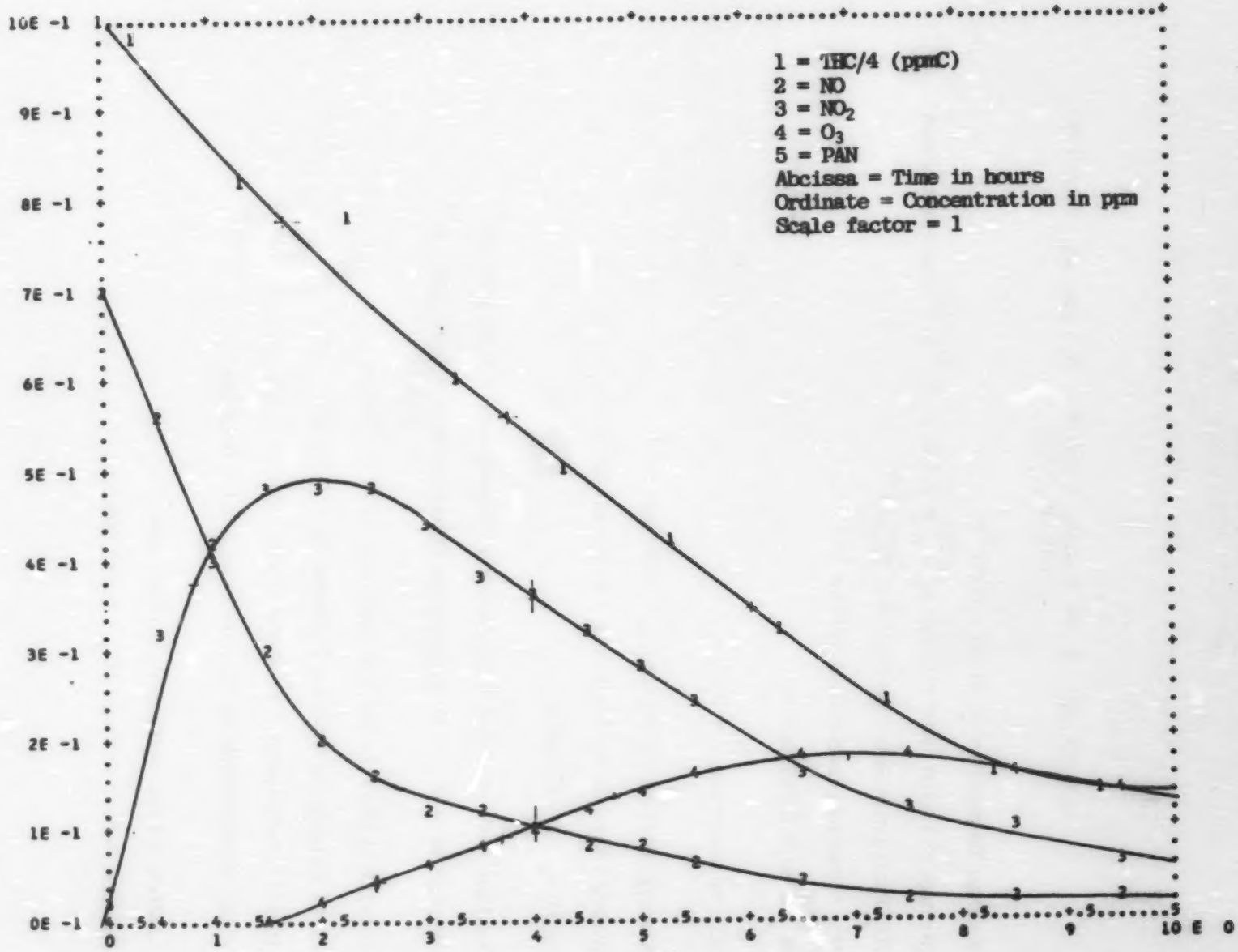
Final Oxidant by Neutral Buffered KI = 0.13 ppm

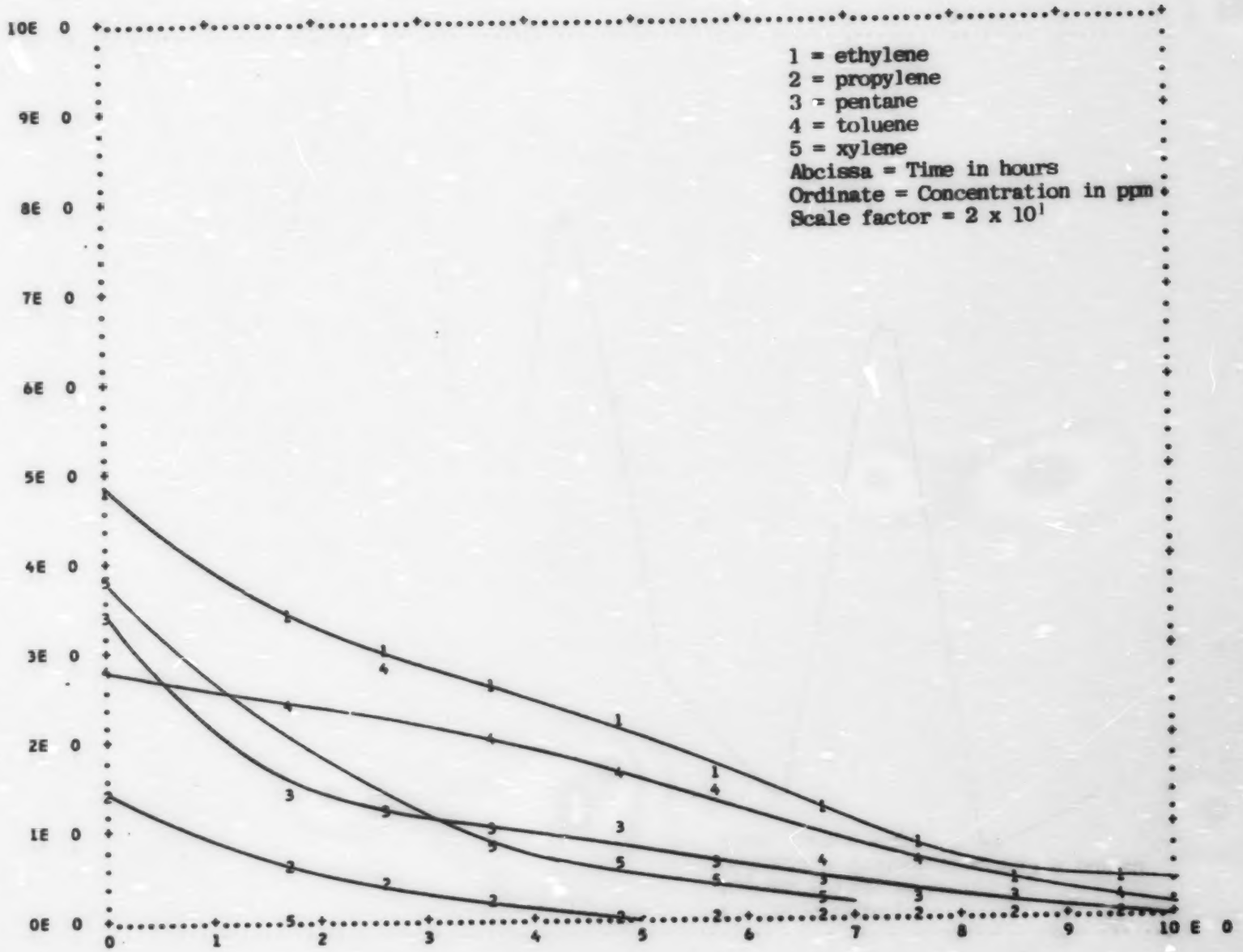
Initial Formaldehyde by Chromatropic Acid = 0 ppm

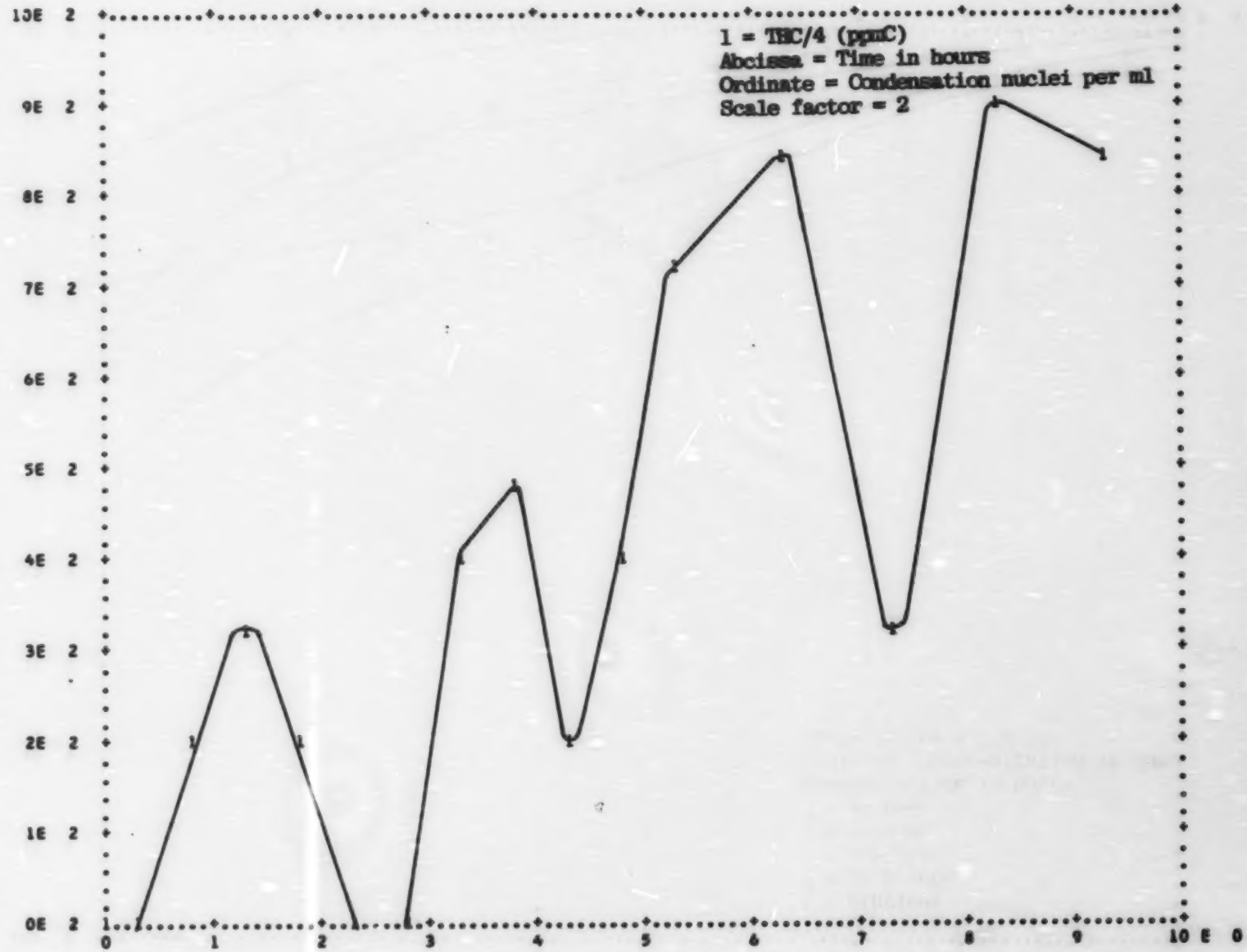
Final Formaldehyde by Chromatropic Acid = 0.09 ppm

Maximum 1-hour Average O_3 = 0.182 ppm

Maximum 1-hour Average NO_2 = 0.483 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0
1
2
3
4
5
6
7
8
9
10 E 0


1 = ethylene
2 = propylene
3 = pentane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10¹
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 2
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0 1 2 3 4 5 6 7 8 9 10 E 0

RUN NO. 17: 4 ppm A-11004, 1 ppm NO_x, 0.3 ppm NO_2, DILUTION
JUNE 13, 1975

Average Temperature = 33.22 ± 0.13 °C

Average Dilution Rate = $0.561 \times 10^{-1} \pm 0.130 \times 10^{-1}$ hr^{-1} chamber volumes

NO_2 Photolysis Rate Constant = 0.72 min^{-1}

NO_2 Formation Rate = 0.11 ppm hr^{-1} (used time at maximum NO_2).

NO_2 Dose = 2.925 ppm hr

NO_2 is corrected for PAN

Maximum Rate of Ozone Formation = 0.02 ppm hr^{-1}

Average Rate of Ozone Formation = 0.01 ppm hr^{-1}

Ozone Dose = 0.425 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.25 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 0.29 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = <.01 ppm

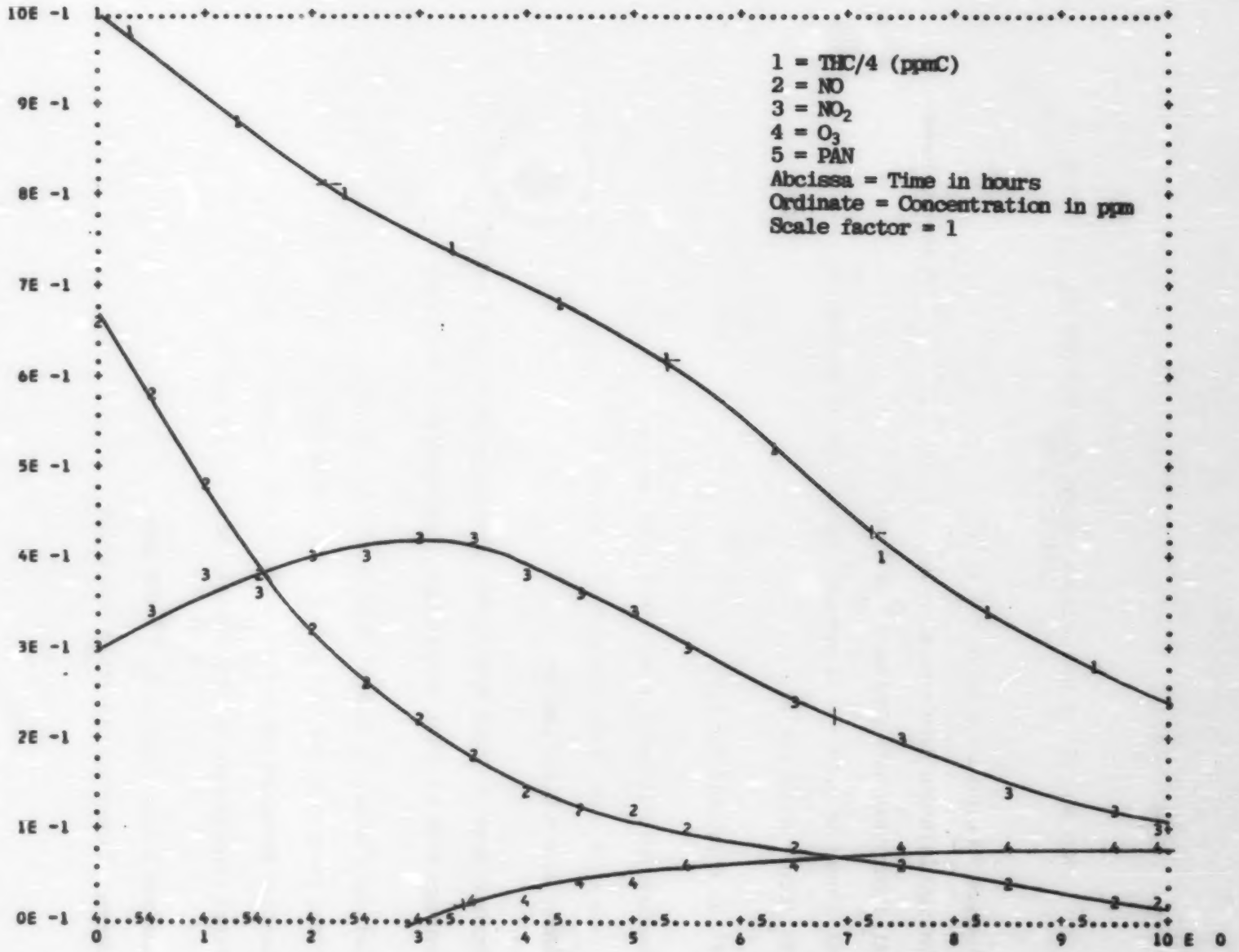
Final Oxidant by Neutral Buffered KI = 0.09 ppm

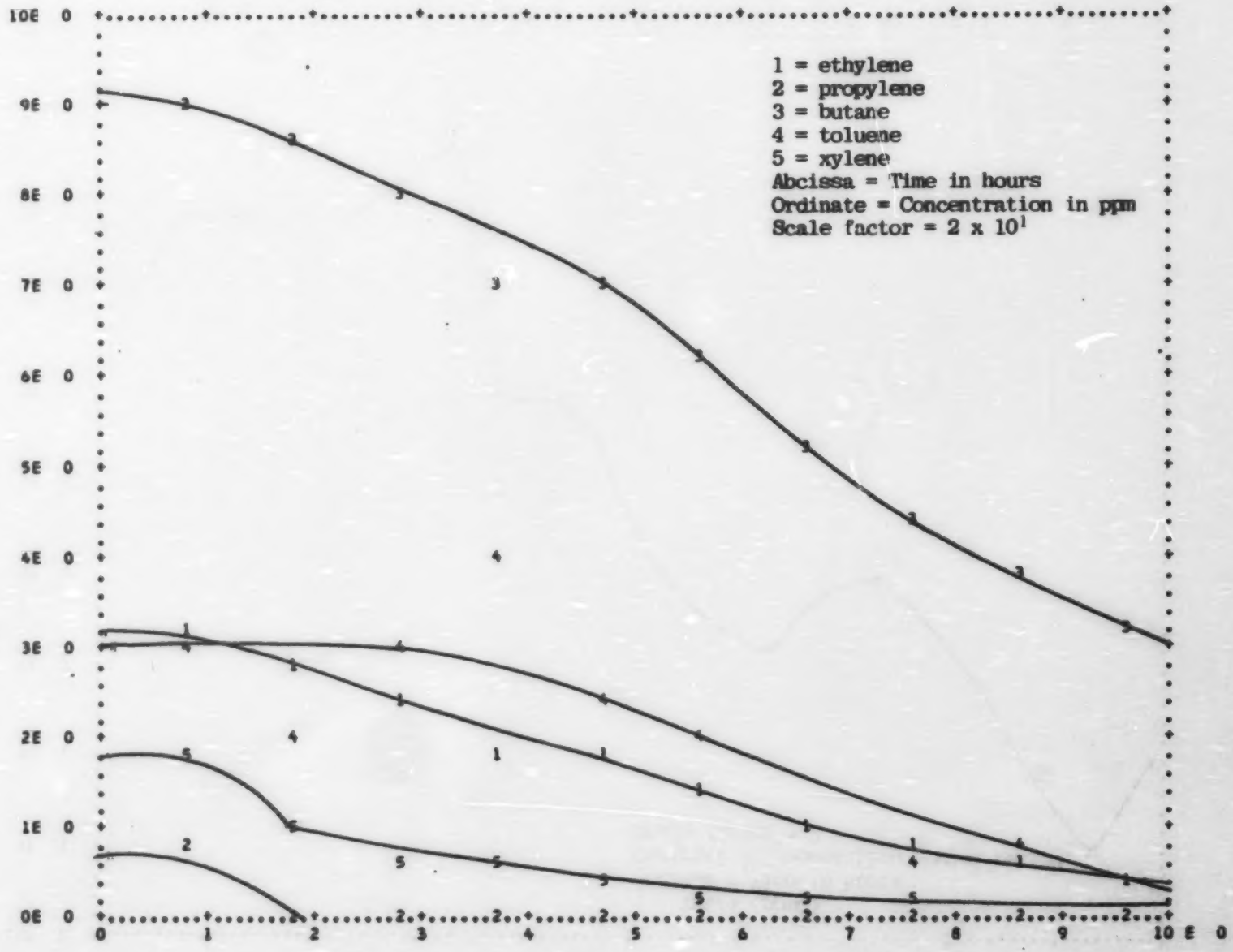
Initial Formaldehyde by Chromatropic Acid = 0 ppm

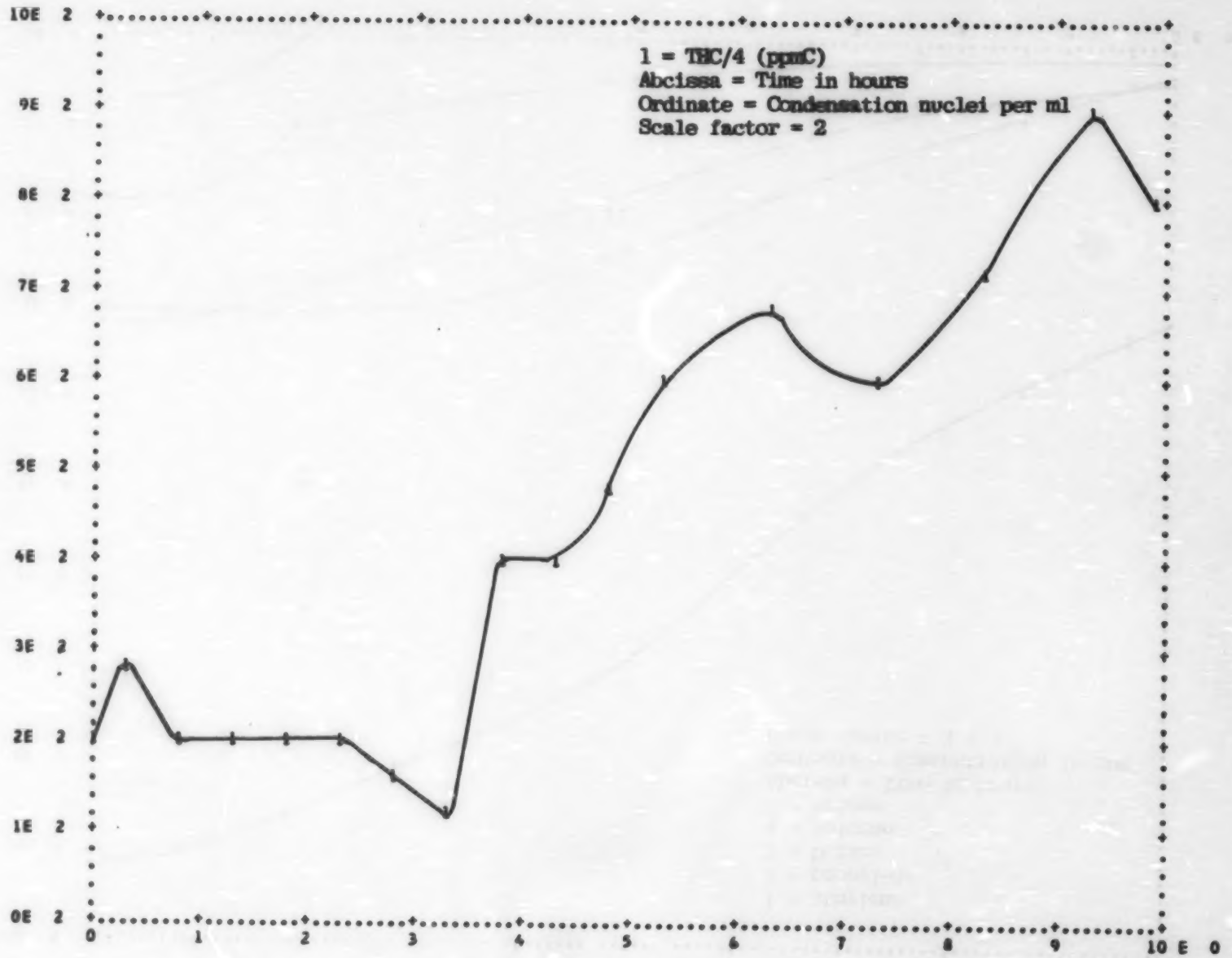
Final Formaldehyde by Chromatropic Acid = 0.09 ppm

Maximum 1-hour Average O_3 = 0.088 ppm

Maximum 1-hour Average NO_2 = 0.417 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = ethylene
2 = propylene
3 = butane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10[1]
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 2
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0
1
2
3
4
5
6
7
8
9
10 E 0

RUN NO. 29: 4 ppm A-11004, 1 ppm NO_x, 0.3 ppm NO_2, DILUTION
JULY 18, 1975[x]

Average Temperature = 34.11 ± 0.33 °C

Average Dilution Rate = $0.590 \times 10^{-1} \pm 0.142 \times 10^{-1}$ hr^{-1} chamber volumes

NO_2 Photolysis Rate Constant = Cannot calculate.
No intersection of NO and O_3 curves.

NO_2 Formation Rate = 0.33 ppm hr^{-1} (used time at maximum NO_2).

NO_2 Dose = 3.290 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0 ppm hr^{-1}

Average Rate of O_3 Formation = 0 ppm hr^{-1}

O_3 Dose = 0.042 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.40 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 0.34 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = <0.01 ppm

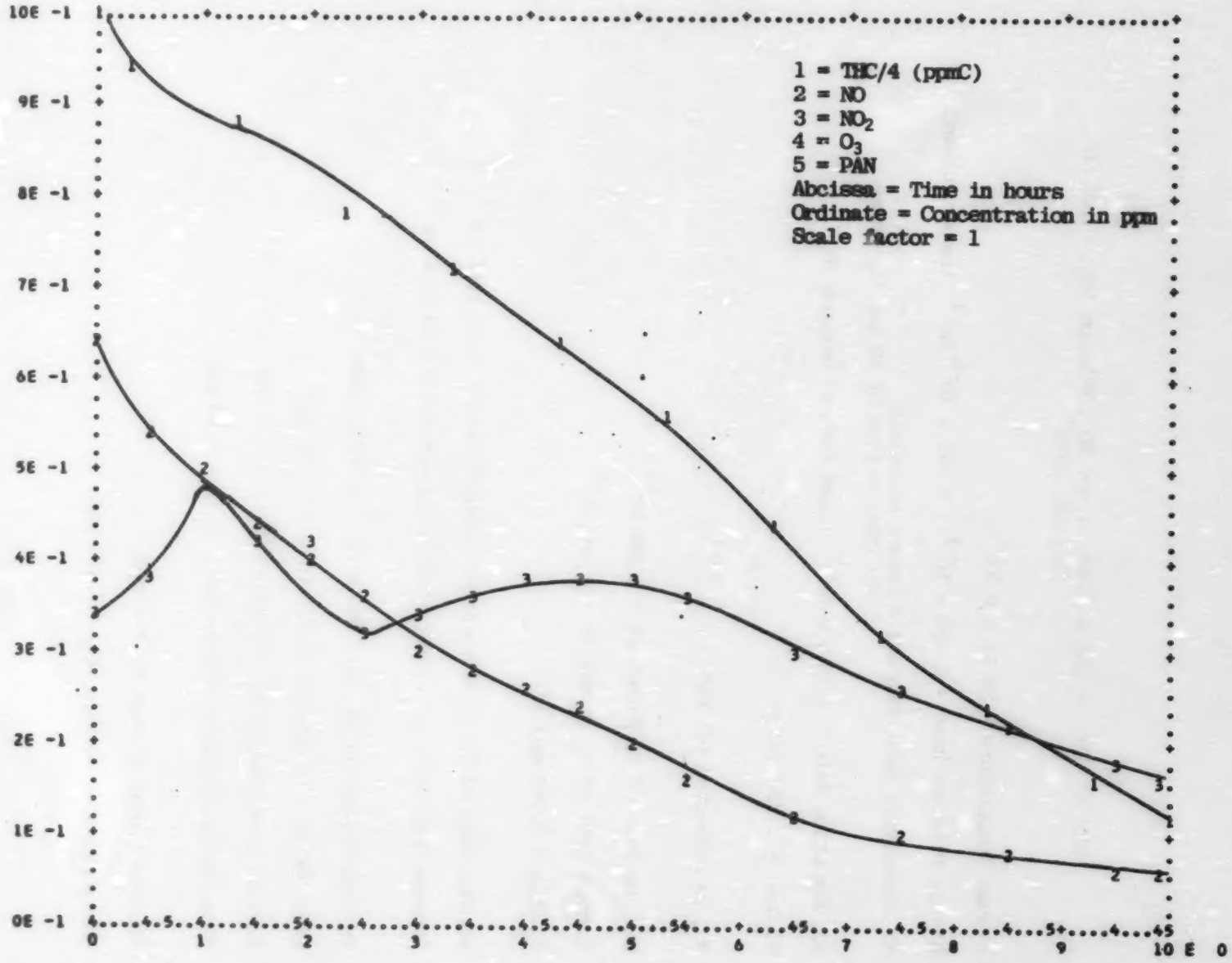
Final Oxidant by Neutral Buffered KI = 0.02 ppm

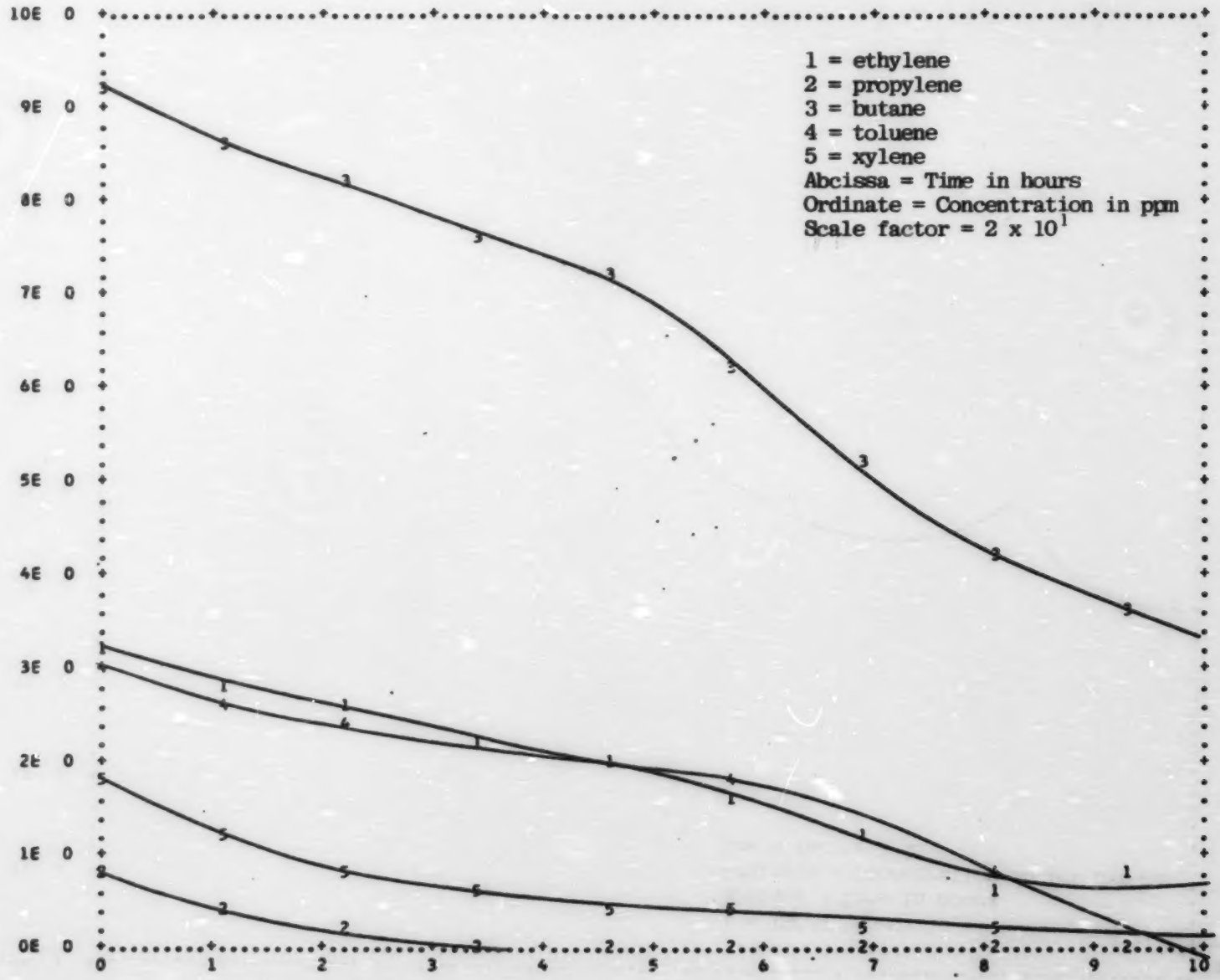
Initial Formaldehyde by Chromatropic Acid = 0 ppm

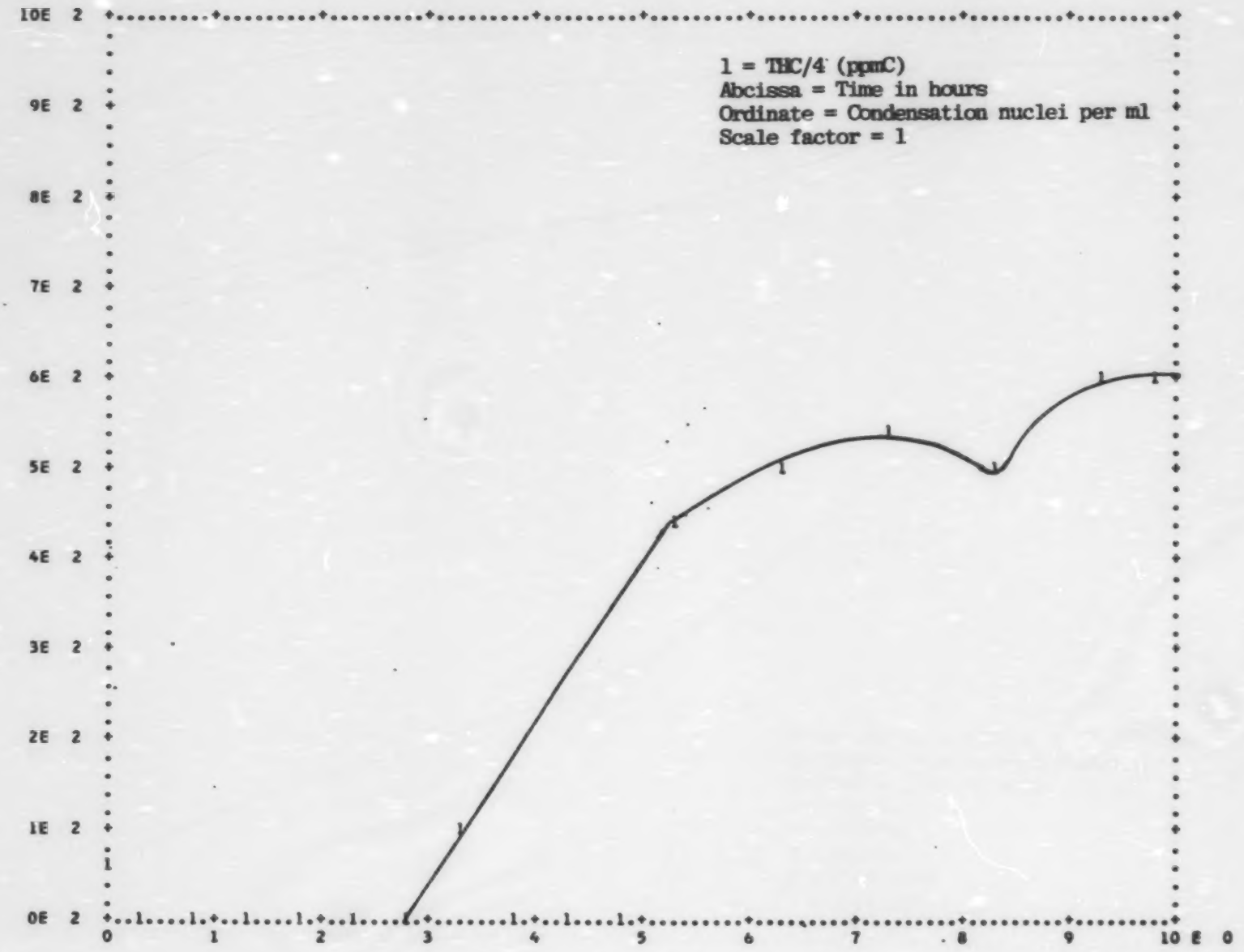
Final Formaldehyde by Chromatropic Acid = 0.10 ppm

Maximum 1-hour Average O_3 = 0 ppm

Maximum 1-hour Average NO_2 = 0.432 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = ethylene
2 = propylene
3 = butane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10[1]
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 1
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0 1 2 3 4 5 6 7 8 9 10 E 0

RUN NO. 15: 4 ppm XL-228, 1 ppm NO_x, 0.3 ppm NO_2, DYNAMIC
JUNE 9, 1975

Average Temperature = 33.15 ± 0.09 ^{o}C

Average Dilution Rate = $0.956 \times 10^{-1} \pm 0.709 \times 10^{-3}$ hr^{-1} chamber volumes

NO_2 Photolysis Rate Constant = 1.00 min^{-1}

NO_2 Formation Rate = 0.36 ppm hr^{-1} (used time at maximum NO_2).

NO_2 Dose = 2.186 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.08 ppm hr^{-1}

Average Rate of O_3 Formation = 0.11 ppm hr^{-1}

O_3 Dose = 1.872 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.65 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 1.54 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = <0.01 ppm

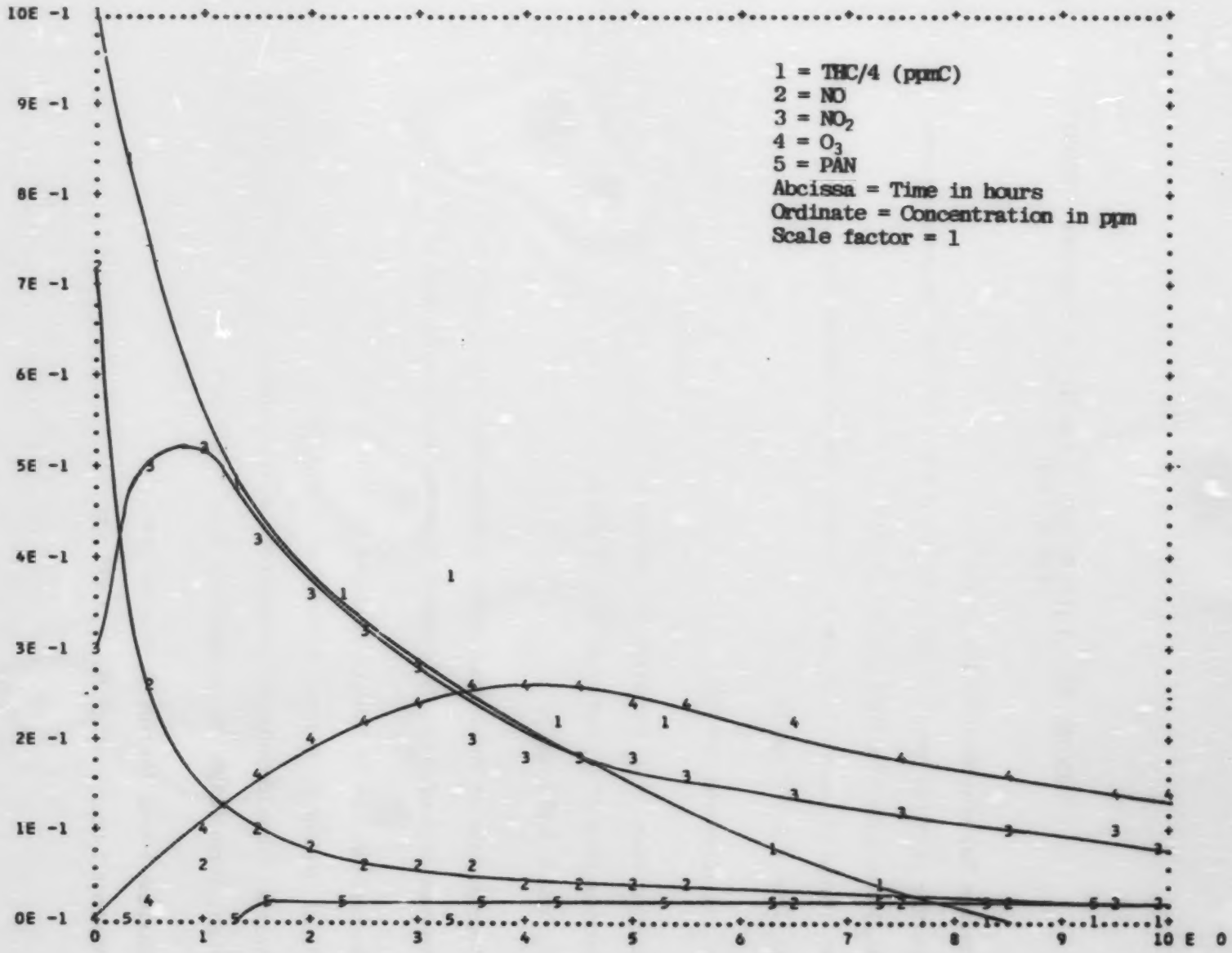
Final Oxidant by Neutral Buffered KI = 0.11 ppm

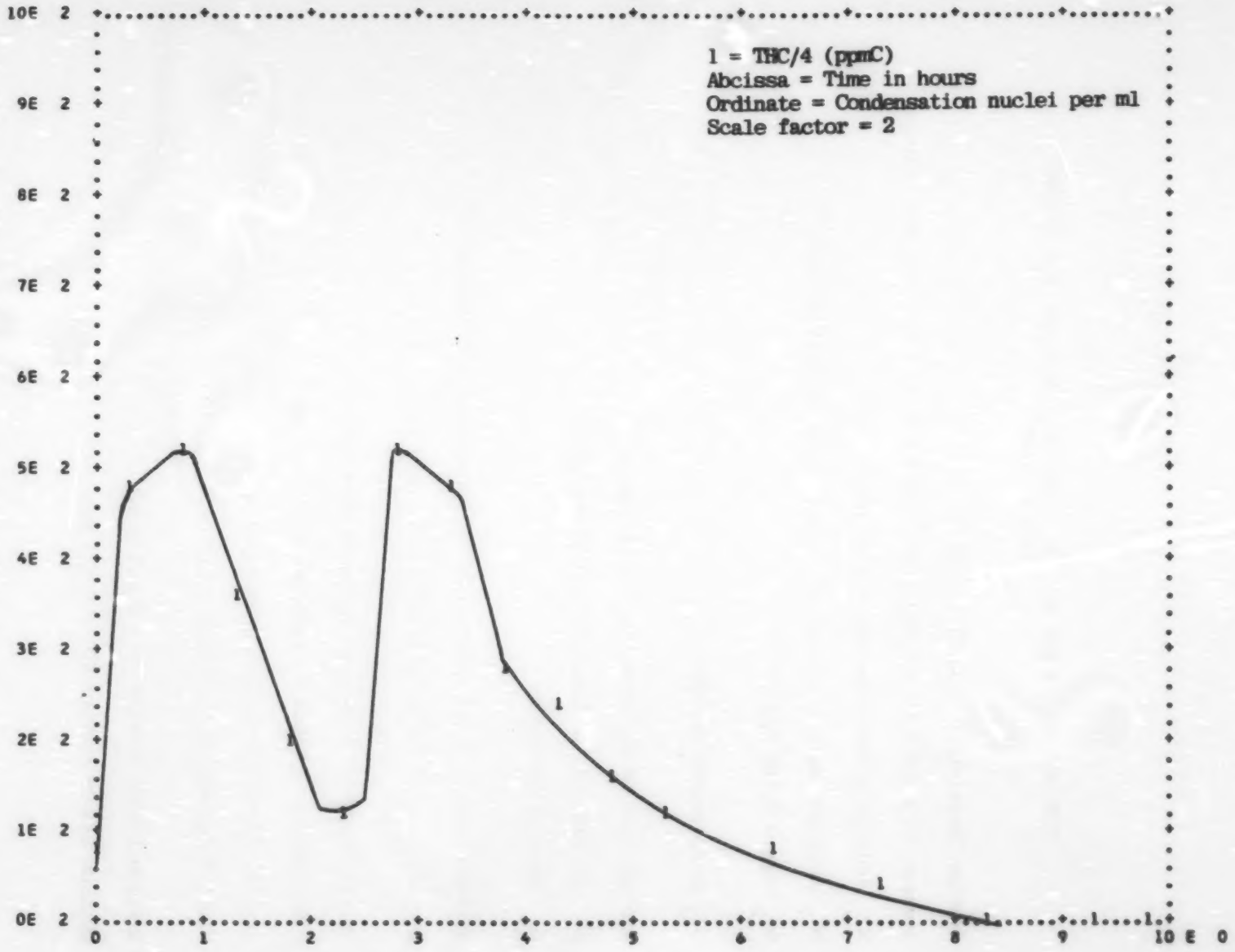
Initial Formaldehydbe by Chromatropic Acid = 0 ppm

Final Formaldehyde by Chromatropic Acid = 0.07 ppm

Maximum 1-hour Average O_3 = 0.263 ppm

Maximum 1-hour Average NO_2 = 0.495 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0
1
2
3
4
5
6
7
8
9
10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 2
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0
1
2
3
4
5
6
7
8
9
10 E 0

RUN NO. 14: 4 ppm XL-288, 1 ppm NO_x, 0.3 ppm NO_2, DYNAMIC
JUNE 6, 1975

Average Temperature = 32.77 ± 0.04 °C

Average Dilution Rate = $0.983 \times 10^{-1} \pm 0.530 \times 10^{-2}$ hr^{-1} chamber volumes

NO_2 Photolysis Rate Constant = 1.33 min^{-1}

NO_2 Formation Rate = 0.8 ppm hr^{-1} (used time at maximum NO_2).

NO_2 Dose = 2.248 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.08 ppm hr^{-1}

Average Rate of O_3 Formation = 0.14 ppm hr^{-1}

O_3 Dose = 1.872 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.74 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 2.1 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = <.01 ppm

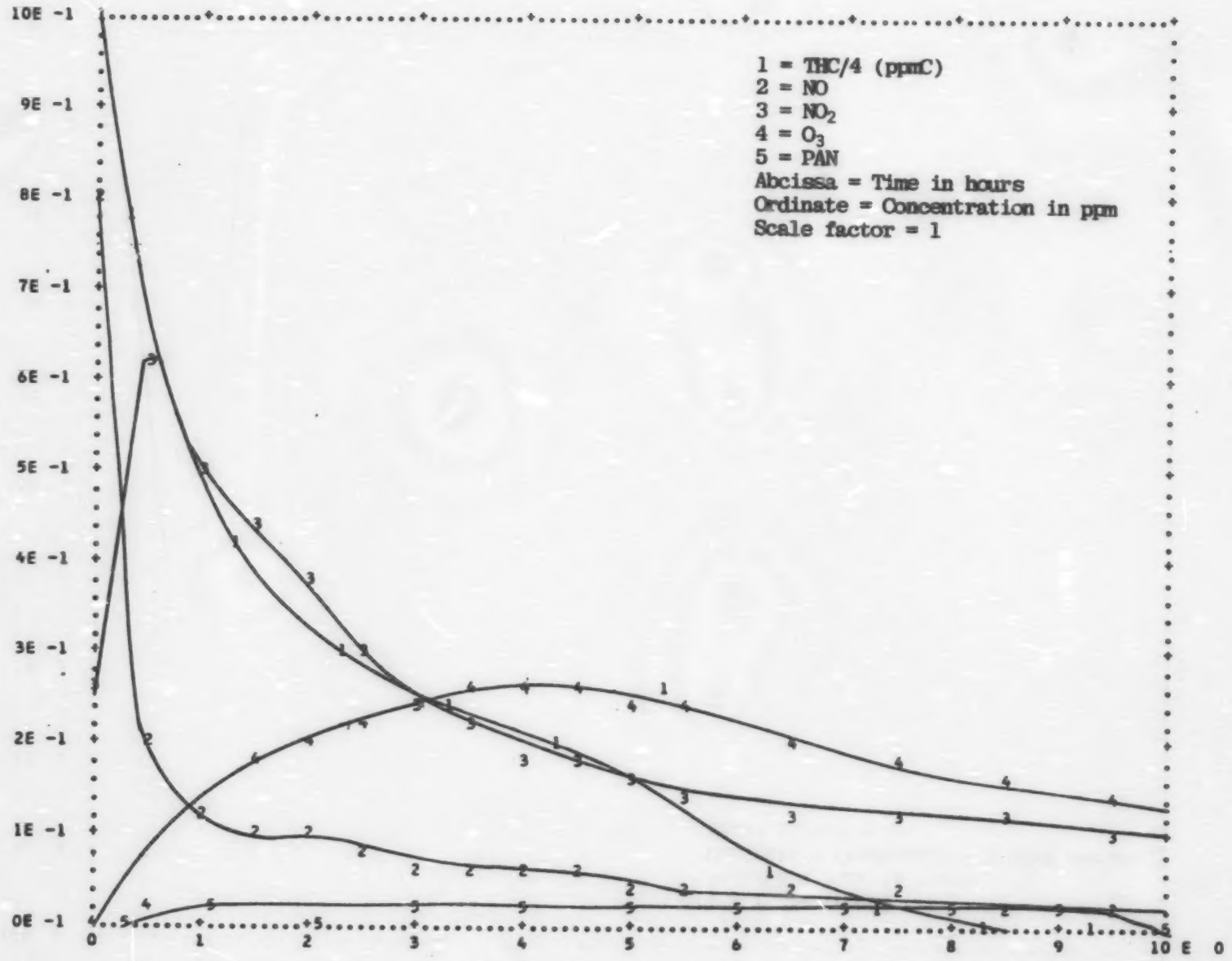
Final Oxidant by Neutral Buffered KI = 0.07 ppm

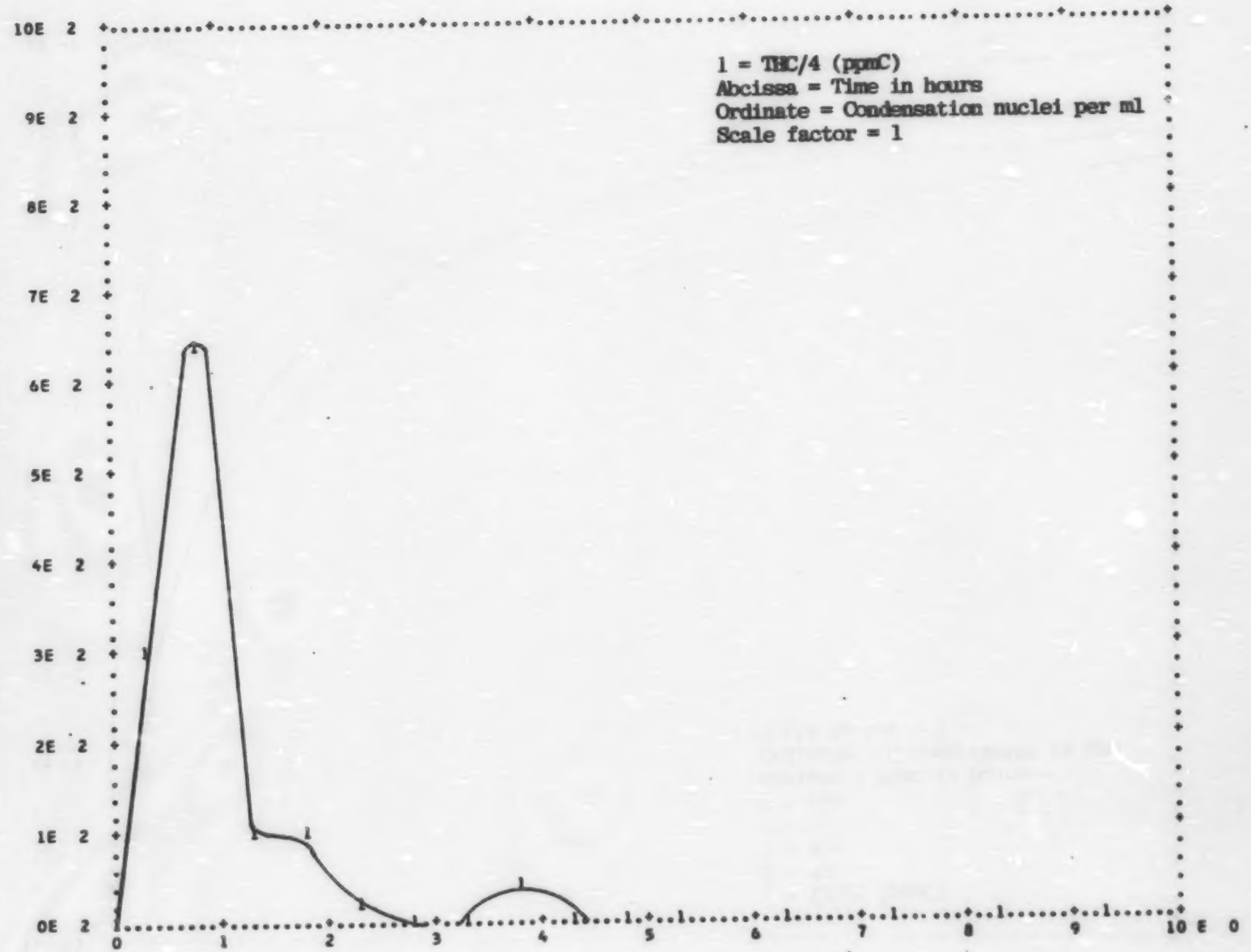
Initial Formaldehyde by Chromatropic Acid = 0 ppm

Final Formaldehyde by Chromatropic Acid = 0.07 ppm

Maximum 1-hour Average O_3 = 0.262 ppm

Maximum 1-hour Average NO_2 = 0.473 ppm


10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0
1
2
3
4
5
6
7
8
9
10 E 0
1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 1
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0
1
2
3
4
5
6
7
8
9
10 E 0

RUN NO. 11: 4 ppm A-11004, 1 ppm NO_x, DYNAMIC
MAY 28, 1975

Average Temperature = 32.93 ± 0.04 °C

Average Dilution Rate = $0.930 \times 10^{-1} \pm 0.700 \times 10^{-3}$ hr^{-1} chamber volumes

NO_2 Photolysis Rate Constant = 0.87 min^{-1}

NO_2 Formation Rate = 0.65 ppm hr^{-1} (used time at maximum NO_2).

NO_2 Dose = 2.438 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.08 ppm hr^{-1}

Average Rate of O_3 Formation = 0.09 ppm hr^{-1}

O_3 Dose = 1.852 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.41 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 0.95 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = <0.01 ppm

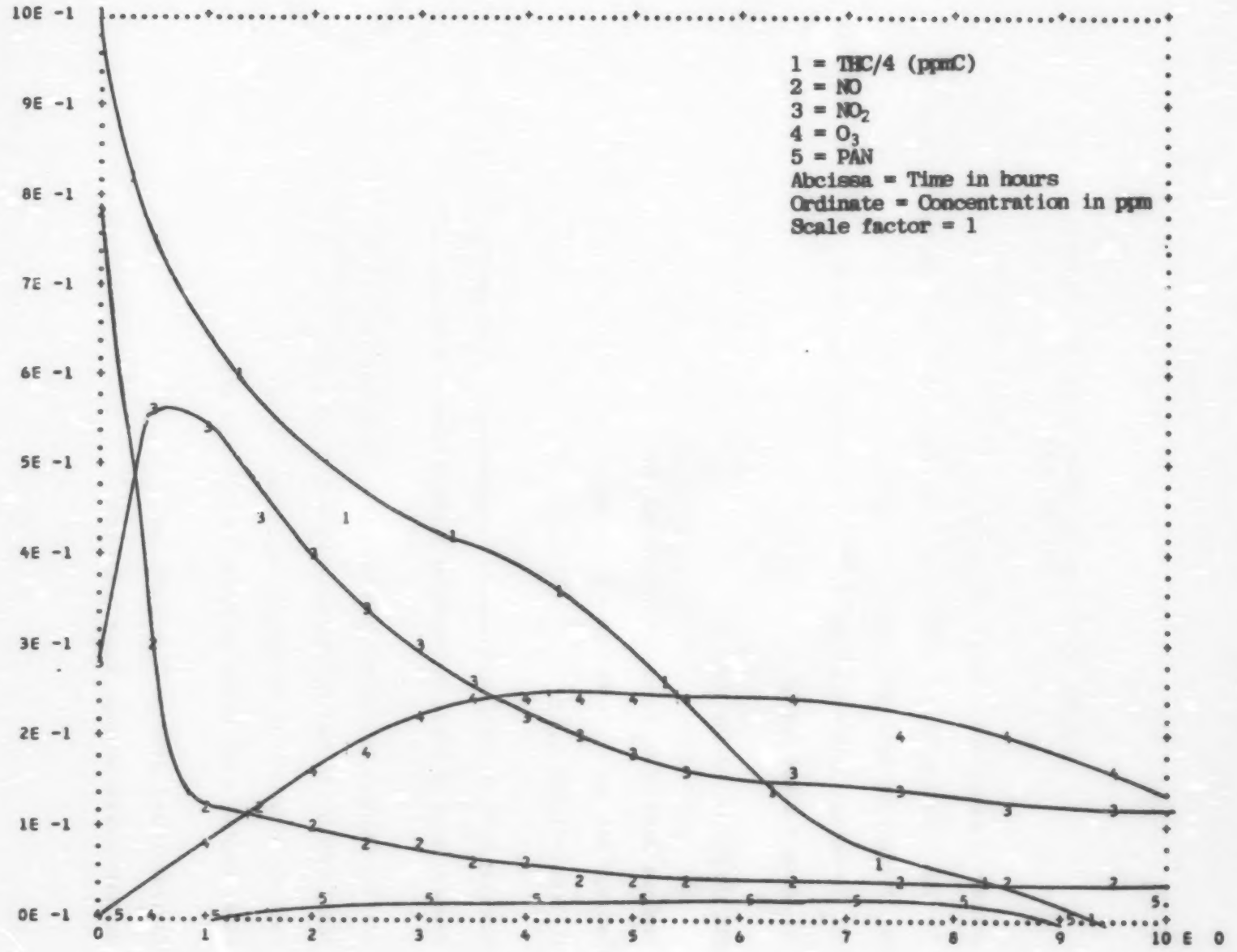
Final Oxidant by Neutral Buffered KI = 0.10 ppm

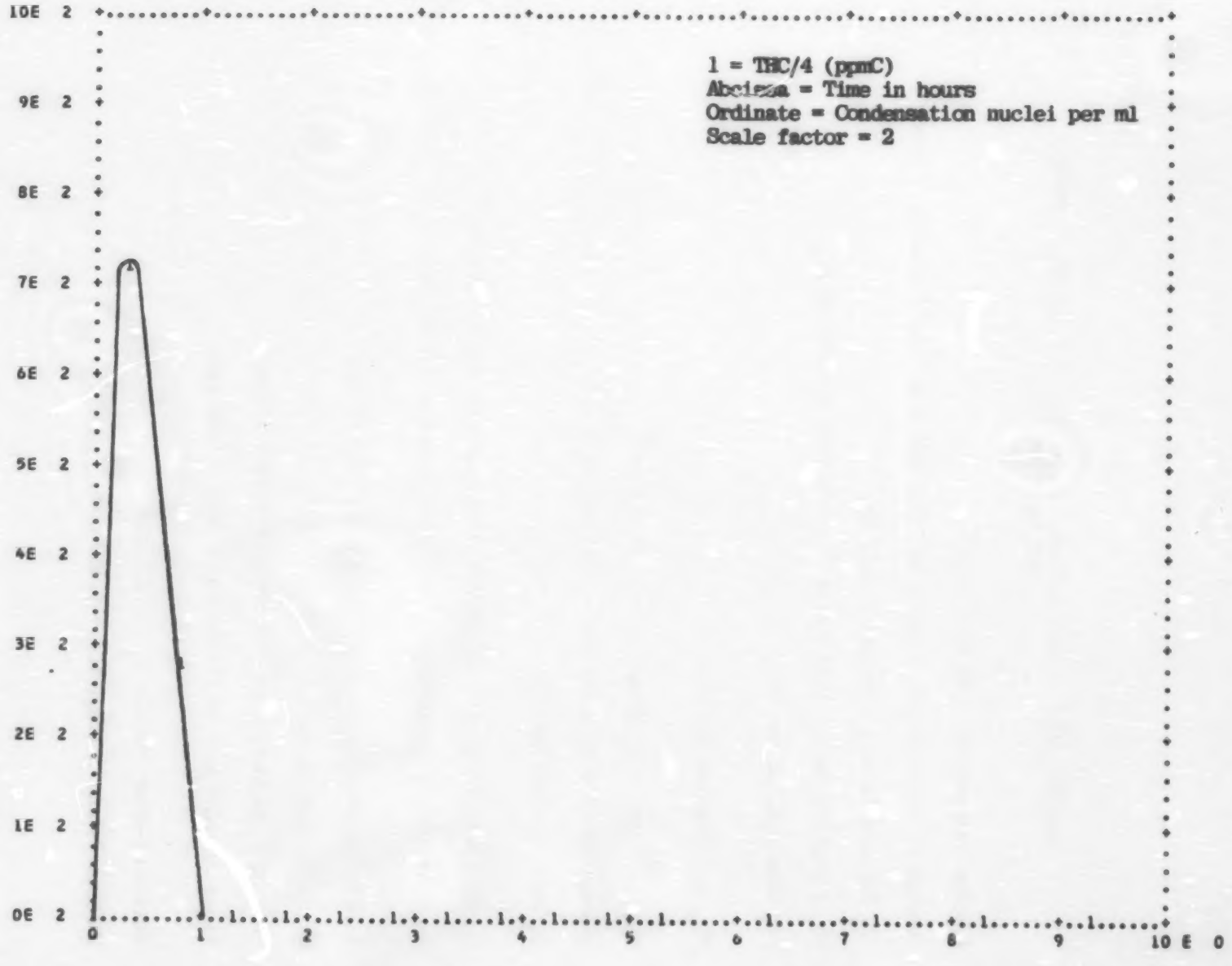
Initial Formaldehyde by Chromatropic Acid = 0 ppm

Final Formaldehyde by Chromatropic Acid = 0.07 ppm

Maximum 1-hour Average O_3 = 0.252 ppm.

Maximum 1-hour Average NO_2 = 0.497 ppm


10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0
1
2
3
4
5
6
7
8
9
10 E 0
1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1


1 = THC/4 (ppmC)
Abciesa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 2
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0
1
2
3
4
5
6
7
8
9
10 E 0

RUN NO. 10R: 4 ppm A-11004, 1 ppm NO_x, 0.3 ppm NO_2, DYNAMIC
MAY 30, 1975

Average Temperature = 32.86 ± 0.05 ^{o}C

Average Dilution Rate = $0.945 \times 10^{-1} \pm 0.689 \times 10^{-3}$ hr^{-1} chamber volumes

NO_2 Photolysis Rate Constant = 1.01 min^{-1}

NO_2 Formation Rate = 0.42 ppm hr^{-1} (used time at maximum NO_2).

NO_2 Dose = 2.232 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.08 ppm hr^{-1}

Average Rate of O_3 Formation = 0.07 ppm hr^{-1}

O_3 Dose = 1.710 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.61 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 0.81 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = <0.01 ppm

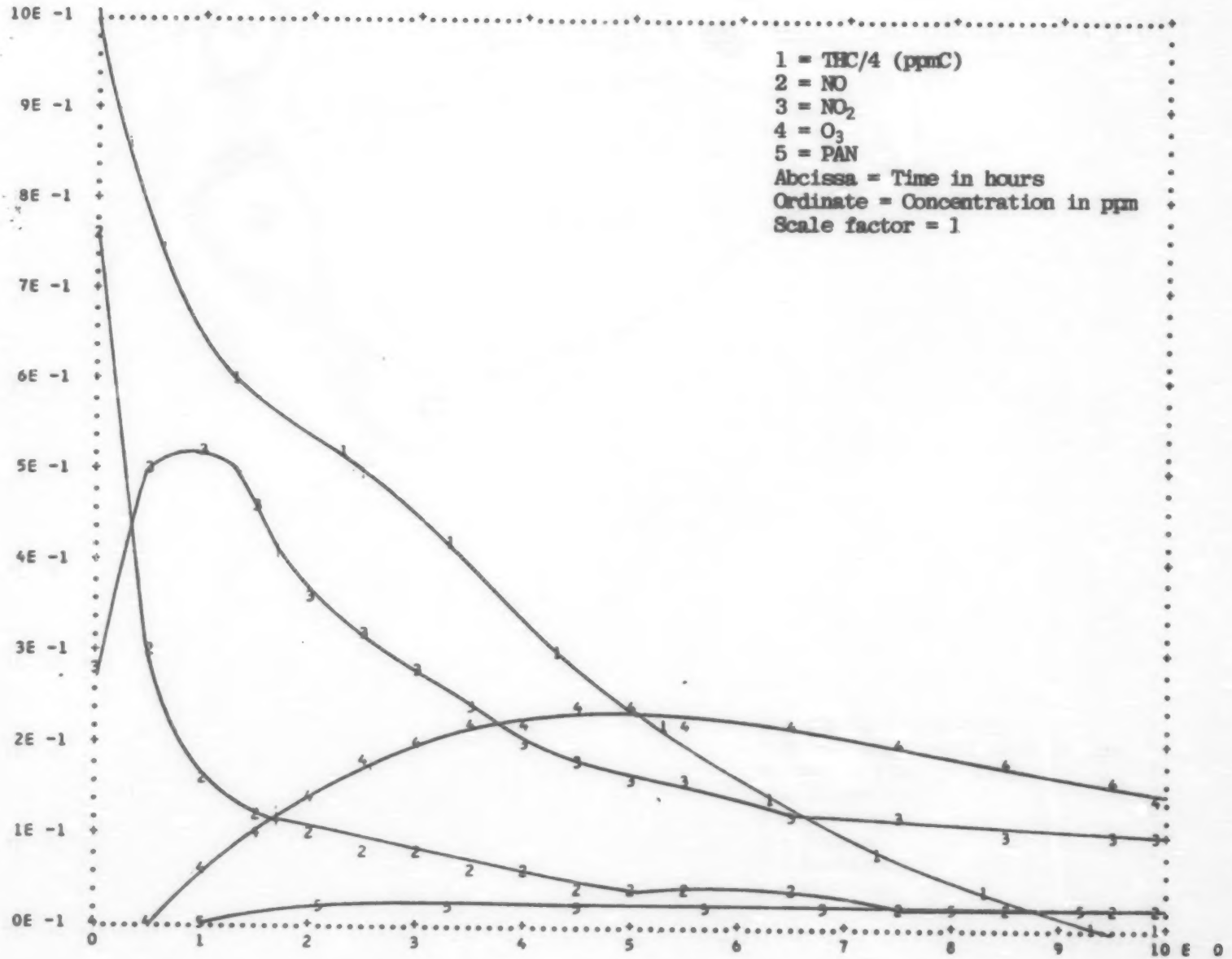
Final Oxidant by Neutral Buffered KI = 0.14 ppm

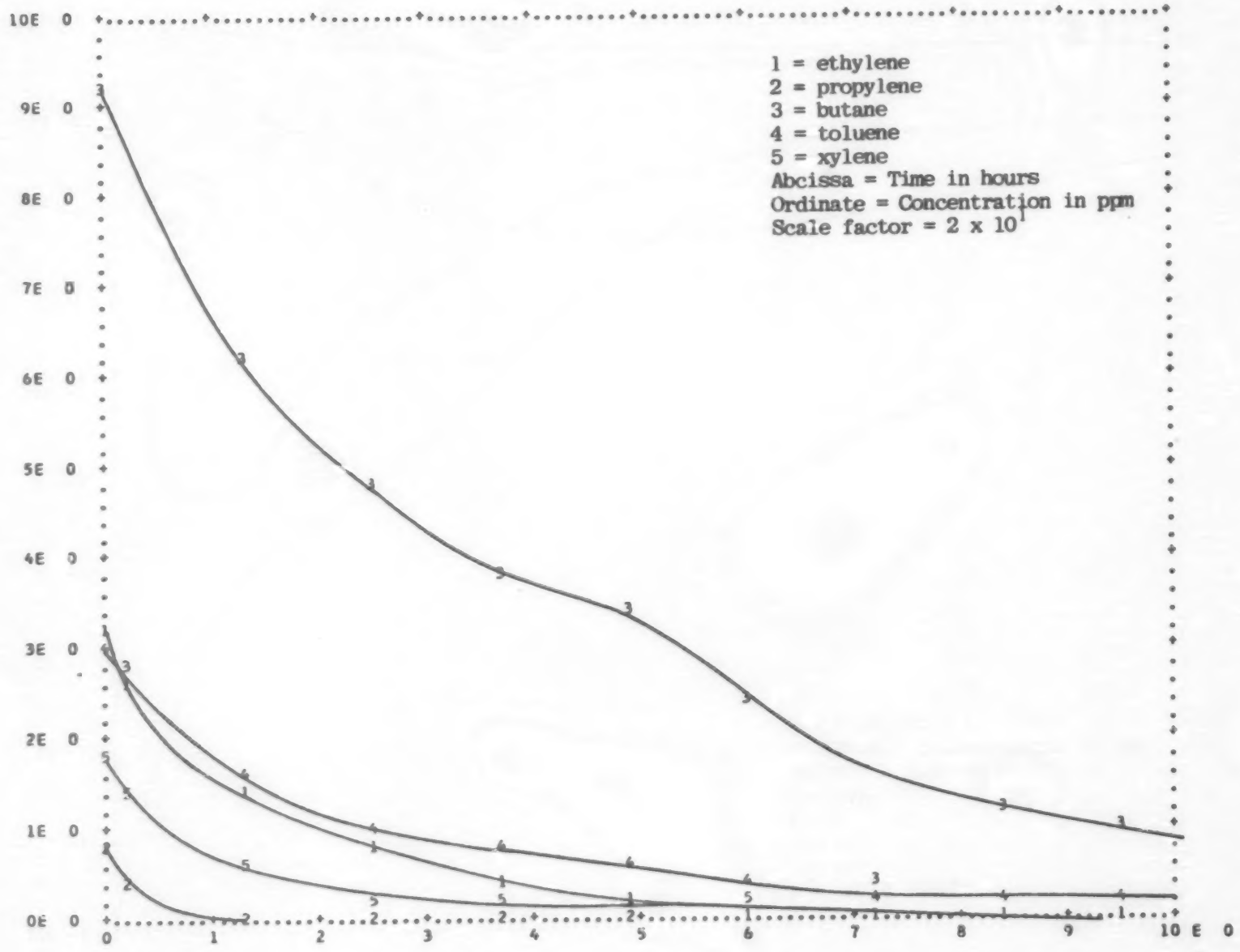
Initial Formaldehyde by Chromatropic Acid = 0 ppm

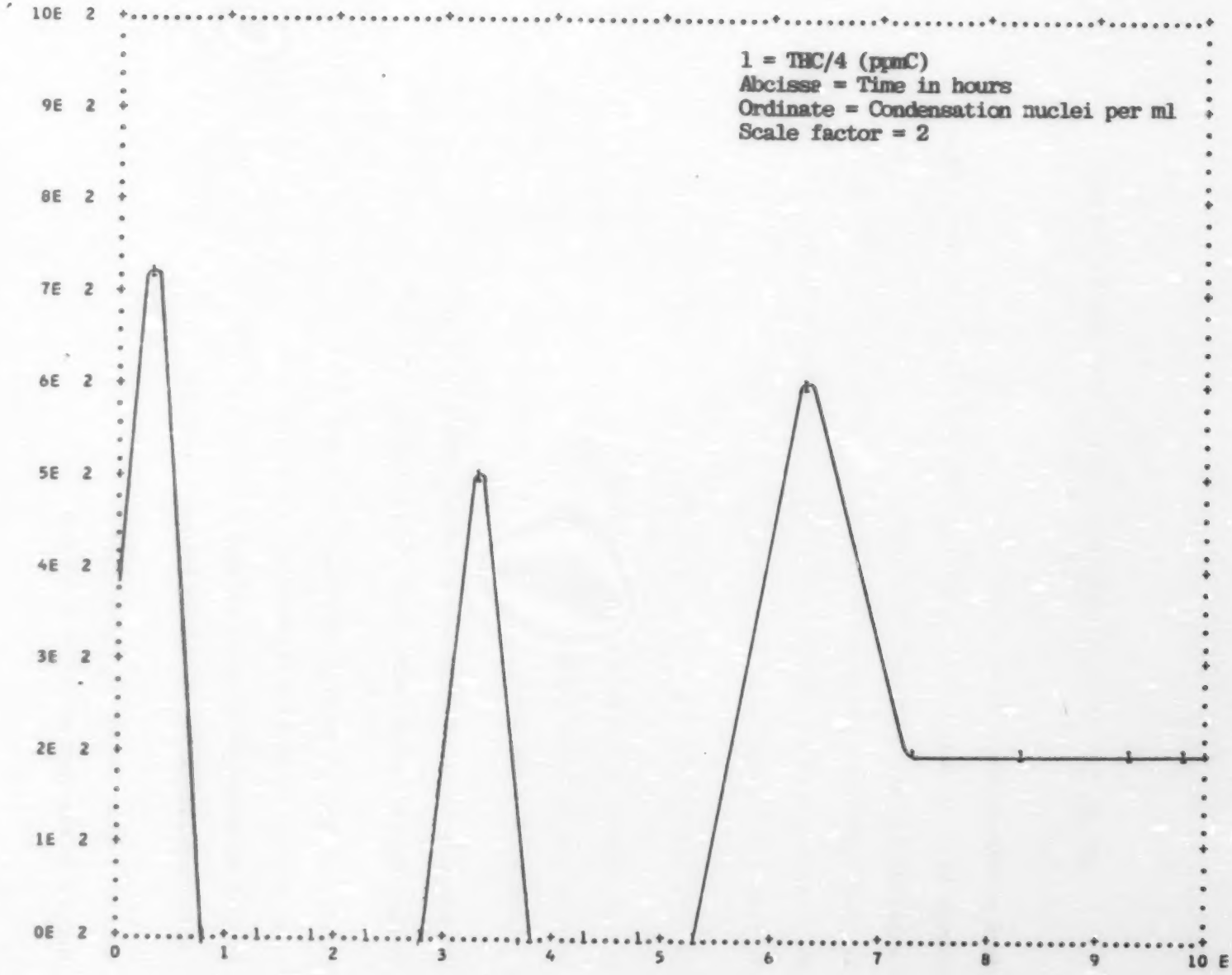
Final Formaldehyde by Chromatropic Acid = 0.09 ppm

Maximum 1-hour Average O_3 = 0.237 ppm

Maximum 1-hour Average NO_2 = 0.490 ppm


10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0
1
2
3
4
5
6
7
8
9
10 E 0
1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1


1 = ethylene
2 = propylene
3 = butane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0
1
2
3
4
5
6
7
8
9
10 E 0


1 = THC/4 (ppmC)
Abcisse = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 2
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0
1
2
3
4
5
6
7
8
9
10 E 0

RUN NO. 26: 4 ppm XL-228, 0.5 ppm NO_x, 0.15 ppm NO_2, STATIC
JULY 9, 1975

Average Temperature = 33.81 ± 0.35 °C

Average Dilution Rate = $0.114 \times 10^{-1} \pm 0.999 \times 10^{-3}$ hr^{-1} chamber volumes

Concentrations are corrected for dilution

NO_2 Photolysis Rate Constant = 0.73 min^{-1}

NO_2 Formation Rate = 0.08 ppm hr^{-1} (used time at maximum NO_2).

NO_2 Dose = 1.582 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.04 ppm hr^{-1}

Average Rate of O_3 Formation = 0.03 ppm hr^{-1}

O_3 Dose = 1.274 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.38 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 0.46 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = 0 ppm

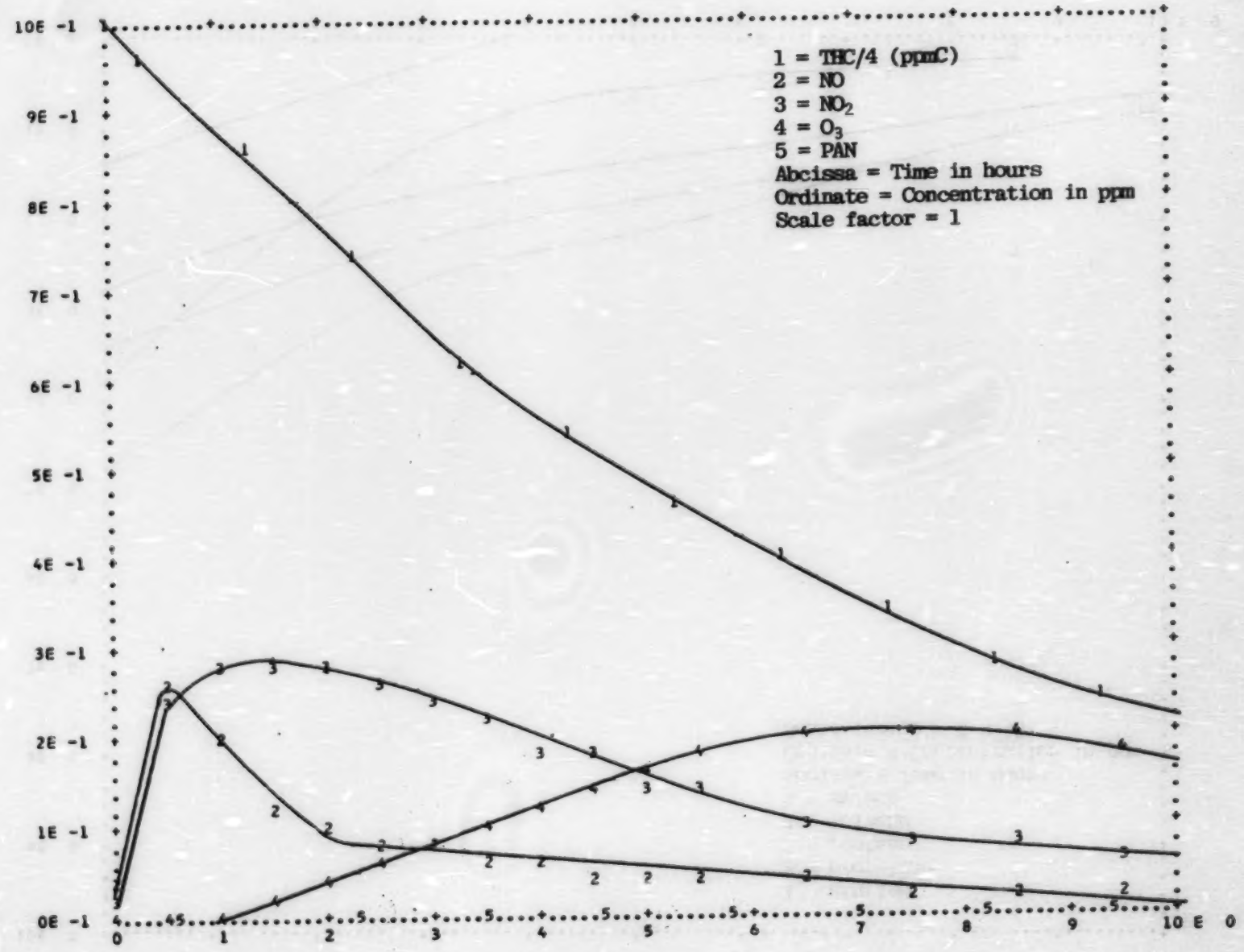
Final Oxidant by Neutral Buffered KI = 0.13 ppm

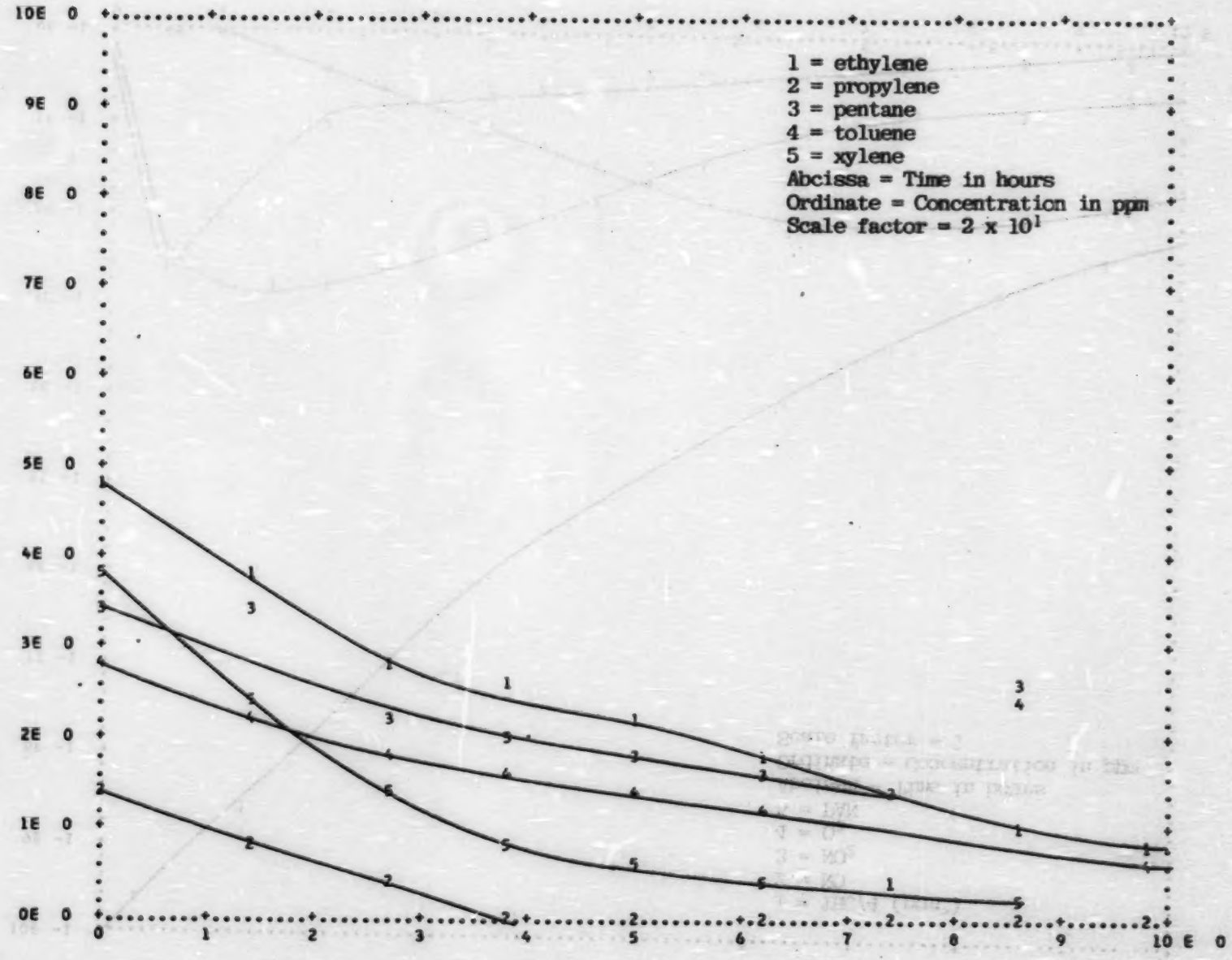
Initial Formaldehyde by Chromatropic Acid = 0 ppm

Final Formaldehyde by Chromatropic Acid = 0.12 ppm

Maximum 1-hour Average O_3 = 0.205 ppm

Maximum 1-hour Average NO_2 = 0.283 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0
1
2
3
4
5
6
7
8
9
10 E 0


1 = ethylene
2 = propylene
3 = pentane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10¹
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0

RUN NO. 30: 4 ppm XL-228, 0.5 ppm NO_x, 0.15 ppm NO_2, STATIC
JULY 21, 1975

Average Temperature = 33.52 ± 0.31 °C

Average Dilution Rate = $0.133 \times 10^{-1} \pm 0.108 \times 10^{-2}$ hr^{-1} chamber volumes

Concentrations are corrected for dilution

NO_2 Photolysis Rate Constant = 0.59 min^{-1}

NO_2 Formation Rate = 0.17 ppm hr^{-1}

NO_2 Dose = 2.039 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.02 ppm hr^{-1}

Average Rate of O_3 Formation = 0.02 ppm hr^{-1}

O_3 Dose = 0.668 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.34 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 0.45 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = <0.01 ppm

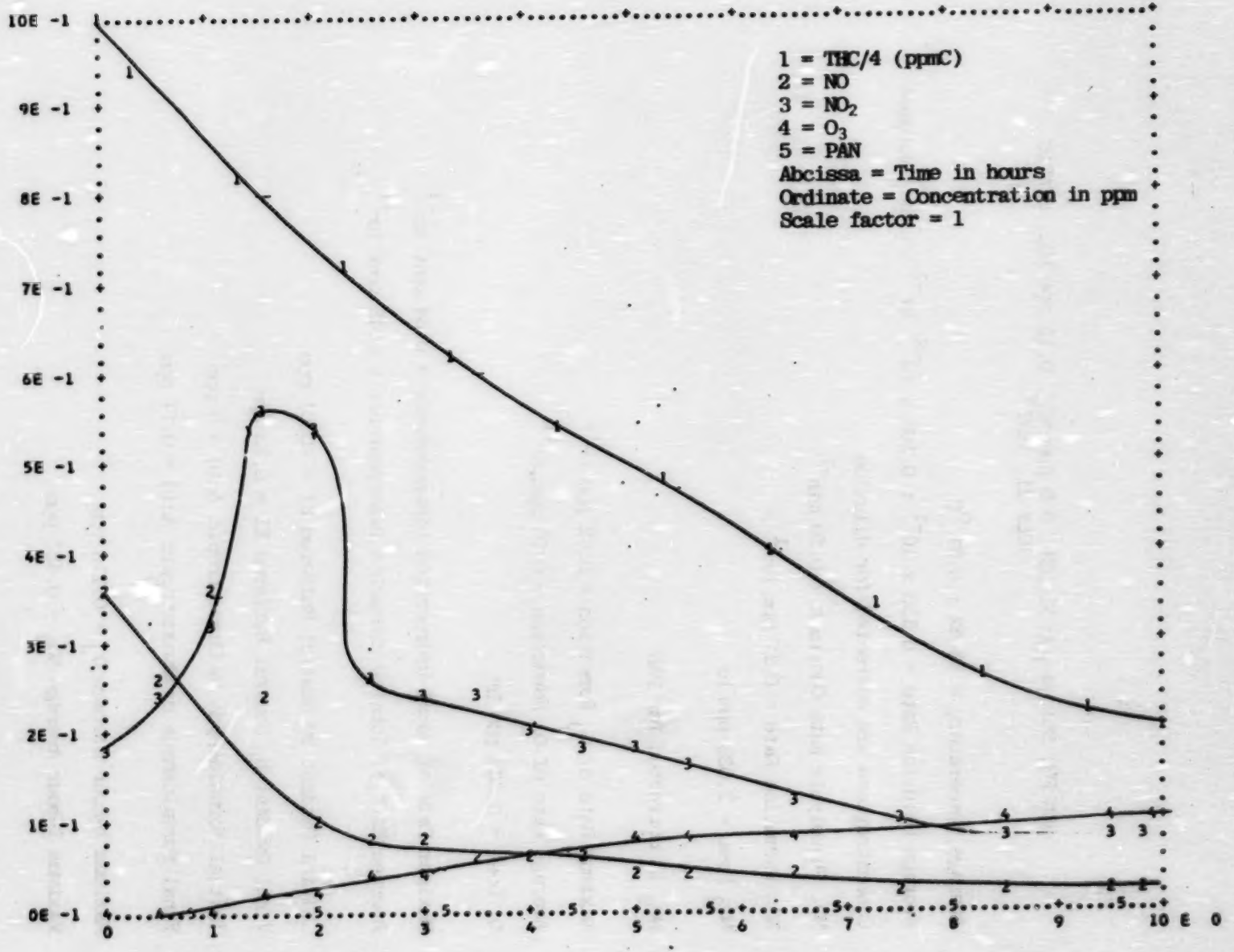
Final Oxidant by Neutral Buffered KI = 0.13 ppm

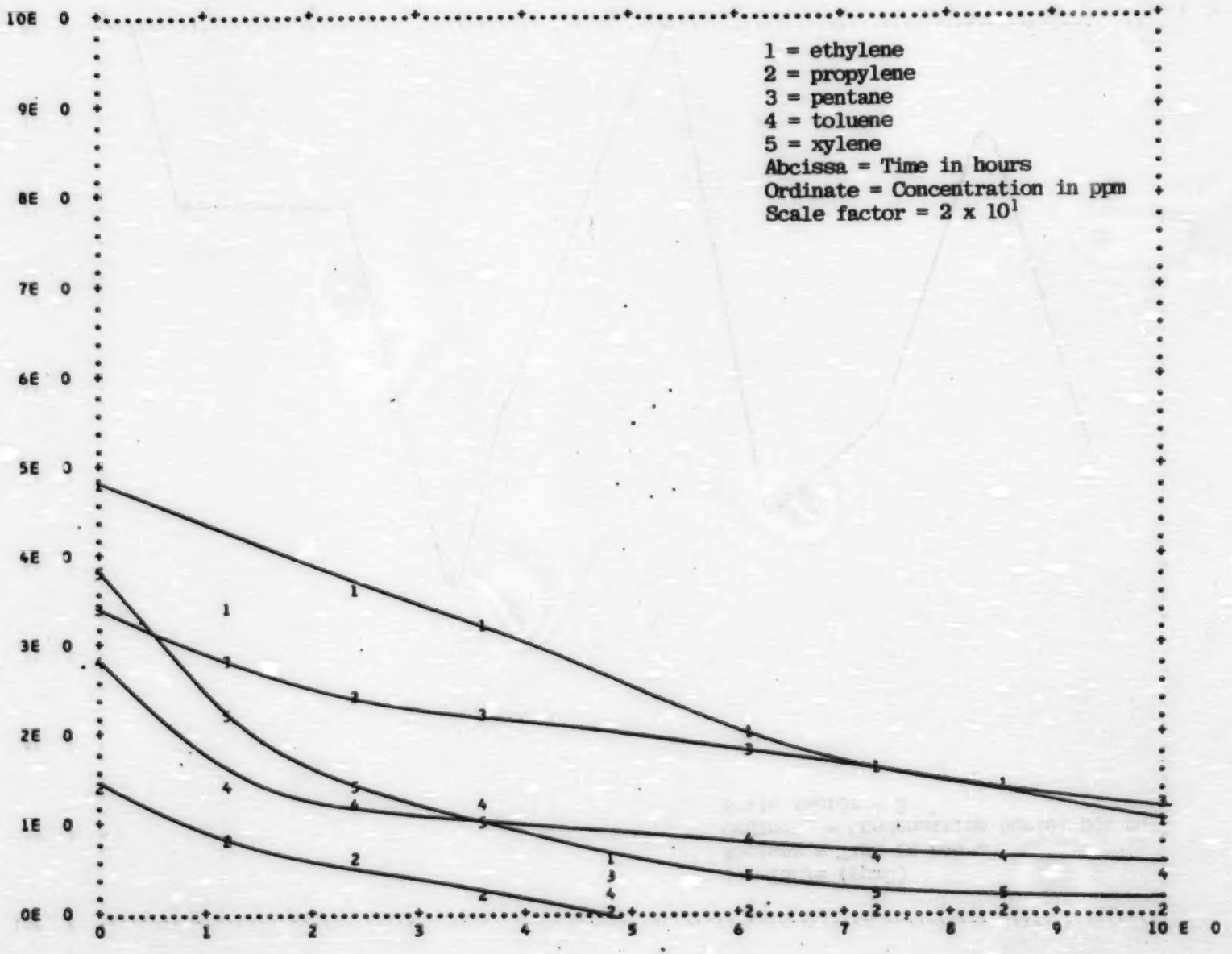
Initial Formaldehyde by Chromatropic Acid = 0 ppm

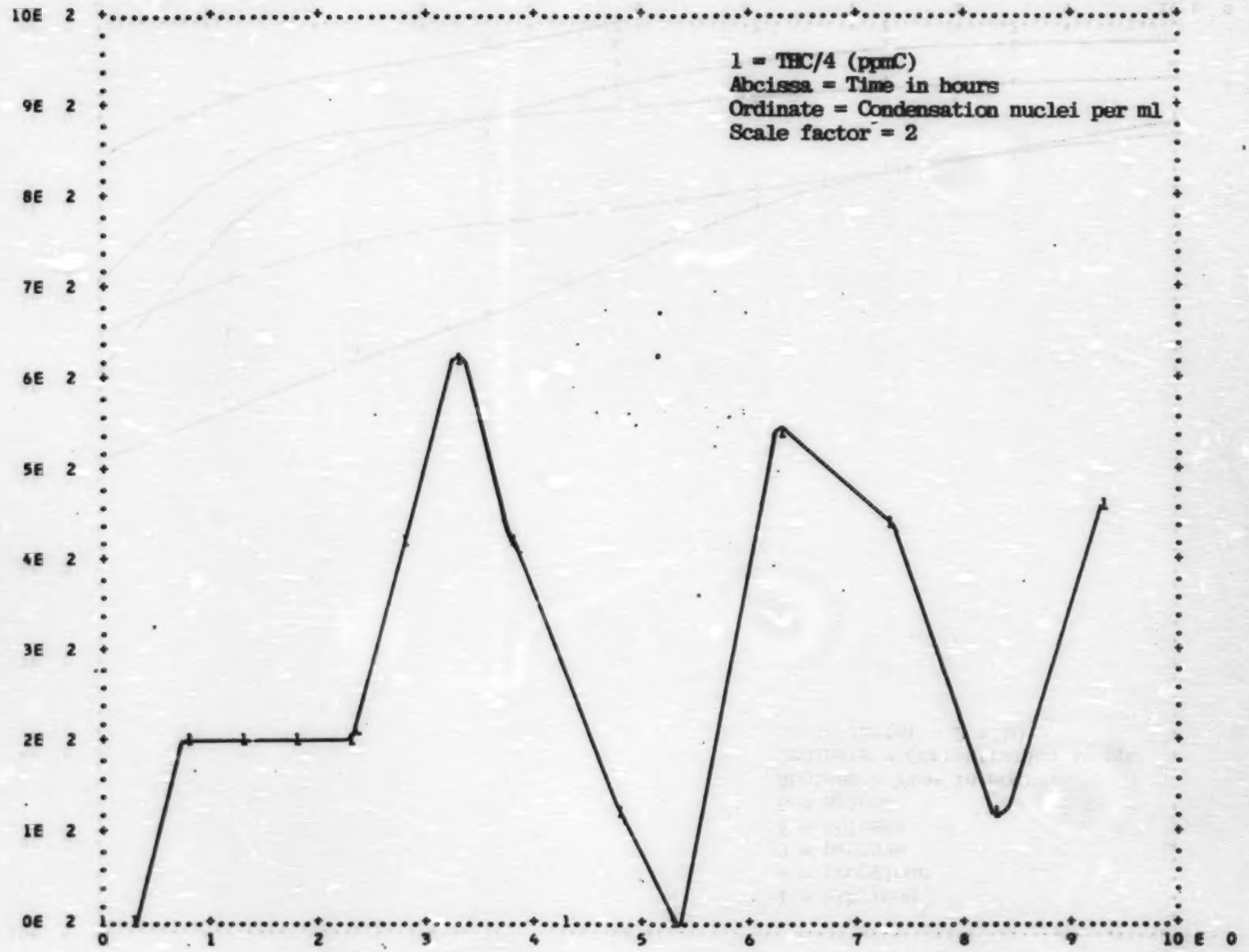
Final Formaldehyde by Chromatropic Acid = 0.17 ppm

Maximum 1-hour Average O_3 = 0.110 ppm

Maximum 1-hour Average NO_2 = 0.483 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = ethylene
2 = propylene
3 = pentane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10[1]
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 2
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0
1
2
3
4
5
6
7
8
9
10 E 0

RUN NO. 12: 4 ppm A-11004, 0.5 ppm NO_x, 0.15 ppm NO_2, STATIC
JUNE 2, 1975

Average Temperature = 32.72 ± 0.02 °C

Average Dilution Rate = $0.140 \times 10^{-1} \pm 0.986 \times 10^{-3}$ hr^{-1} chamber volumes

Concentrations are corrected for dilution

NO_2 Photolysis Rate Constant = 0.89 min^{-1}

NO_2 Formation Rate = 0.09 ppm hr^{-1} (used time at maximum NO_2).

NO_2 Dose = 1.824 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.03 ppm hr^{-1}

Average Rate of O_3 Formation = 0.03 ppm hr^{-1}

O_3 Dose = 1.108 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.24 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 0.34 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = <0.01 ppm

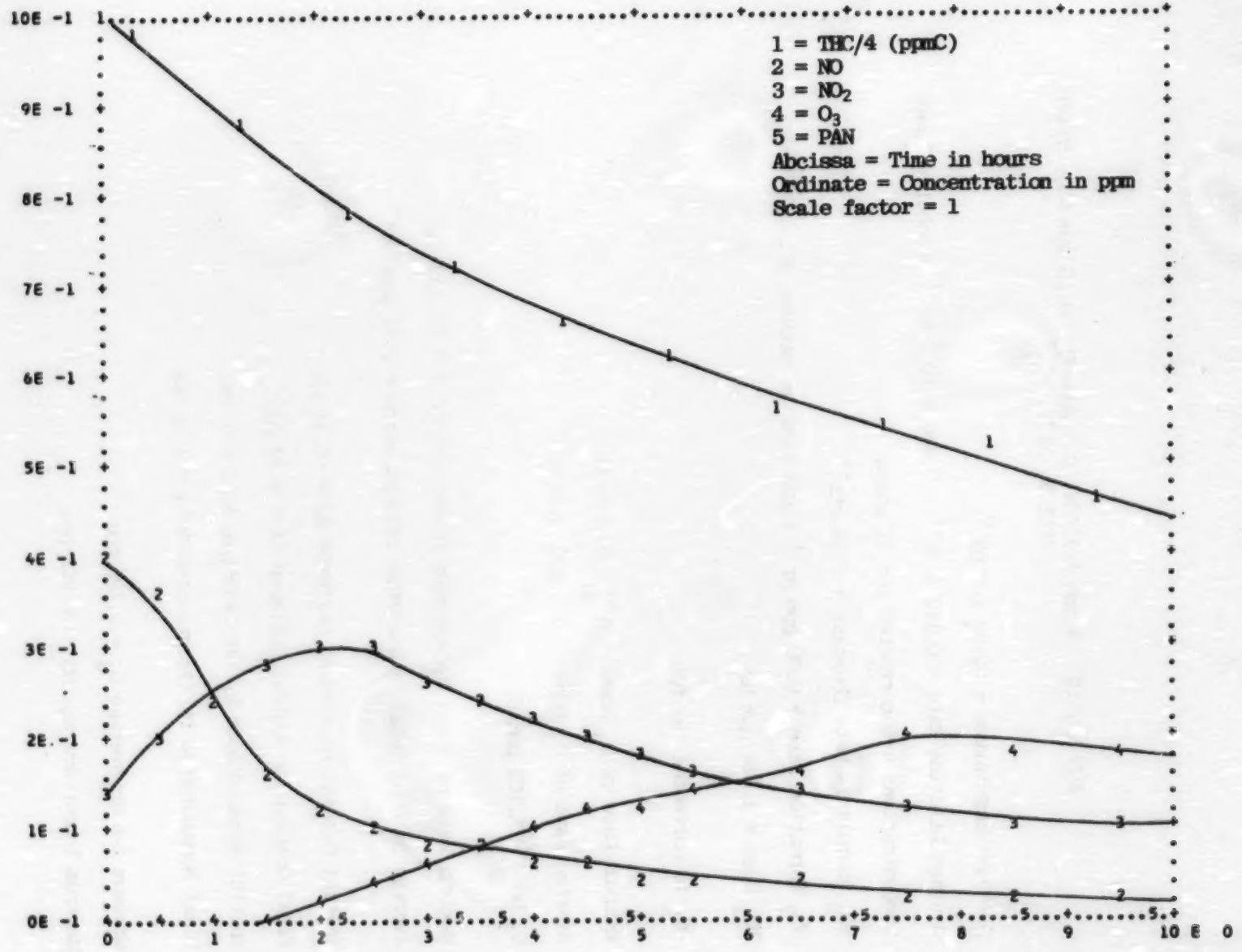
Final Oxidant by Neutral Buffered KI = 0.17 ppm

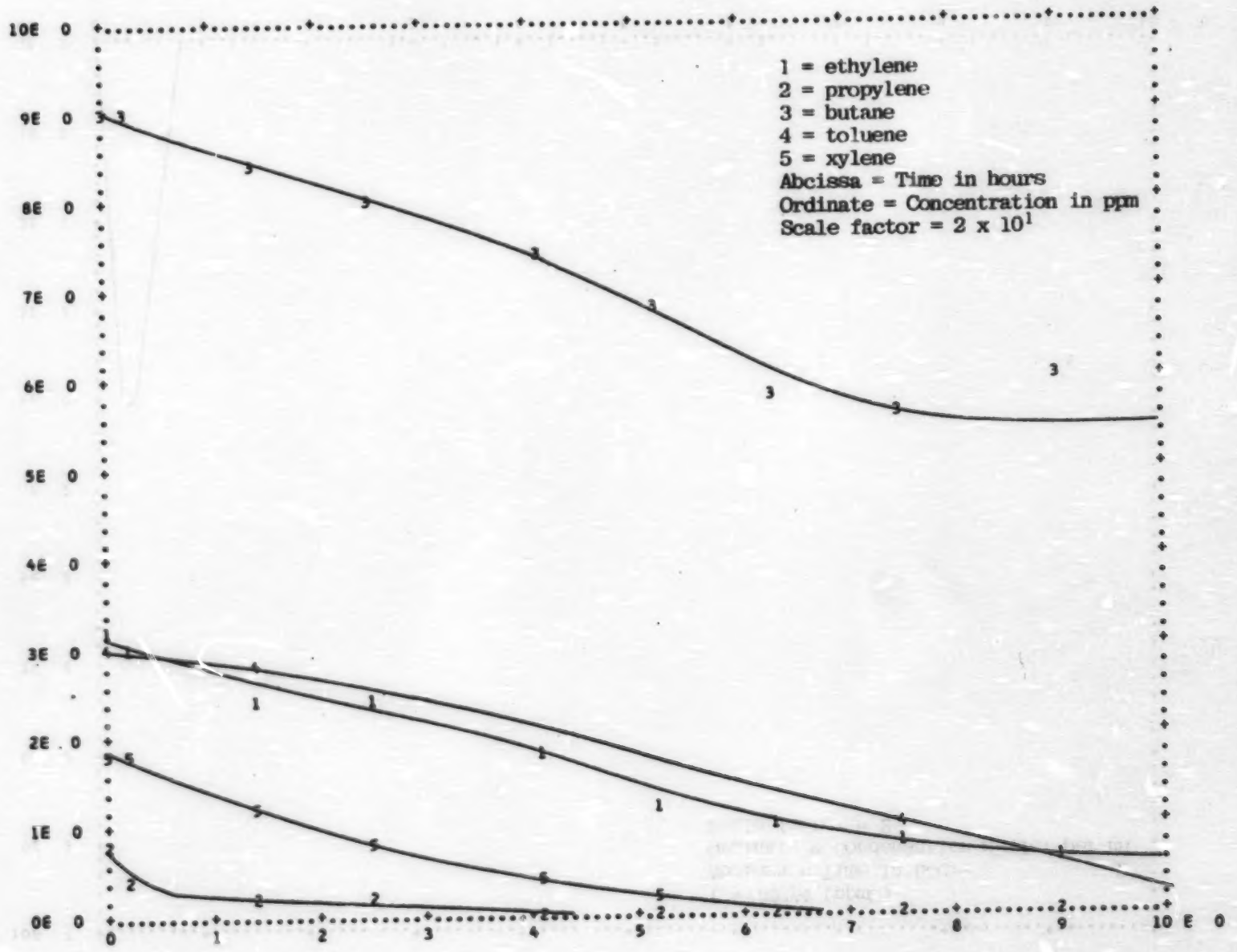
Initial Formaldehyde by Chromatropic Acid = 0 ppm

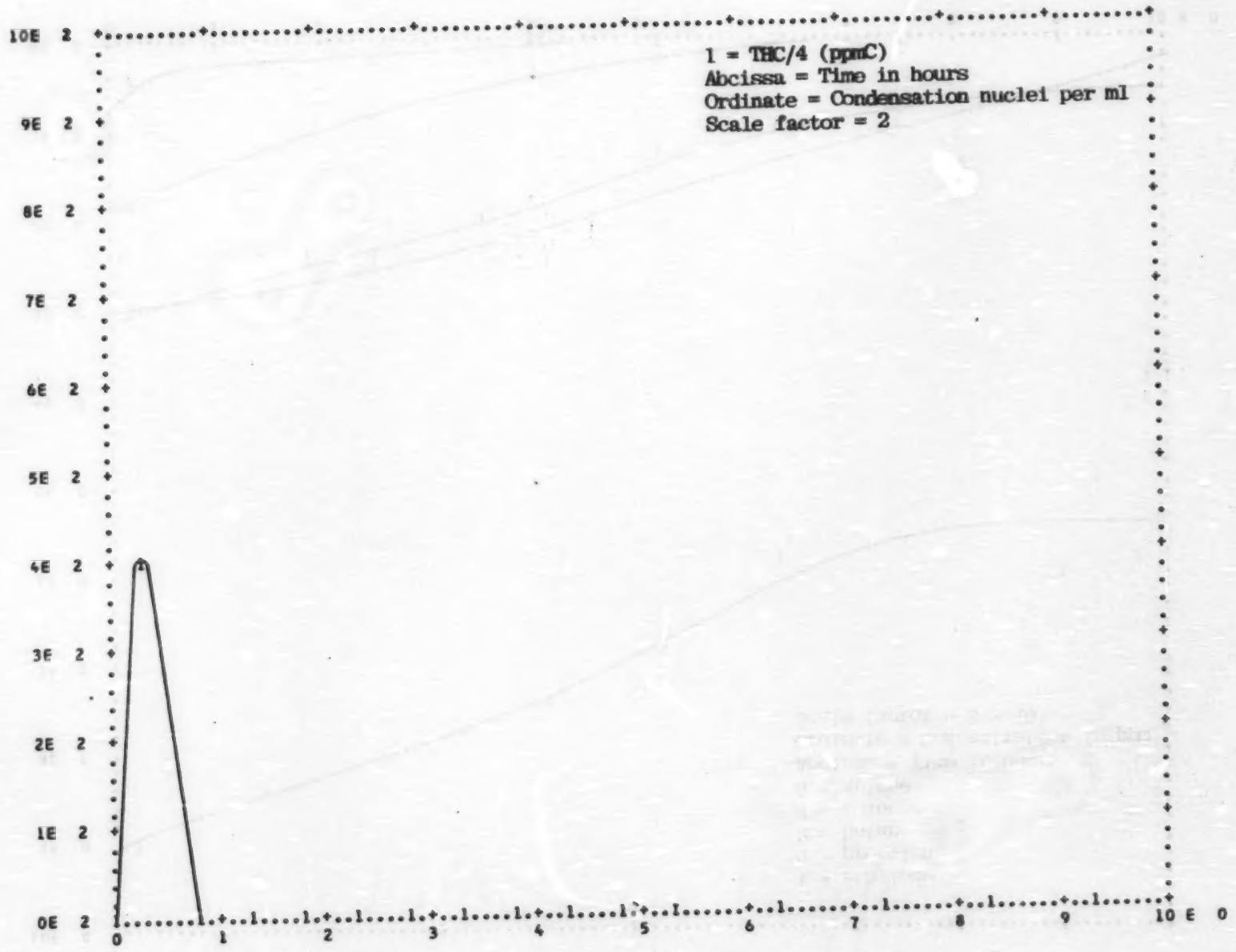
Final Formaldehyde by Chromatropic Acid = 0.14 ppm

Maximum 1-hour Average O_3 = 0.195 ppm

Maximum 1-hour Average NO_2 = 0.292 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0
1
2
3
4
5
6
7
8
9
10 E 0


1 = ethylene
2 = propylene
3 = butane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10[1]
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 2
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0
1
2
3
4
5
6
7
8
9
10 E 0

RUN NO. 31: 4 ppm A-11004, 0.5 ppm NO_x, 0.15 ppm NO_2, STATIC
JULY 23, 1975

Average Temperature = 33.97 ± 0.38 ^{o}C

Average Dilution Rate = $0.121 \times 10^{-1} \pm 0.881 \times 10^{-3}$ hr^{-1} chamber volumes

Concentrations are corrected for dilution

NO_2 Photolysis Rate Constant = 0.61 min^{-1}

NO_2 Formation Rate = 0.08 ppm hr^{-1} (used time at maximum NO_2).

NO_2 Dose = 2.001 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.09 ppm hr^{-1}

Average Rate of O_3 Formation = 0.06 ppm hr^{-1}

O_3 Dose = 0.306 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.16 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 0.21 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = <0.01 ppm

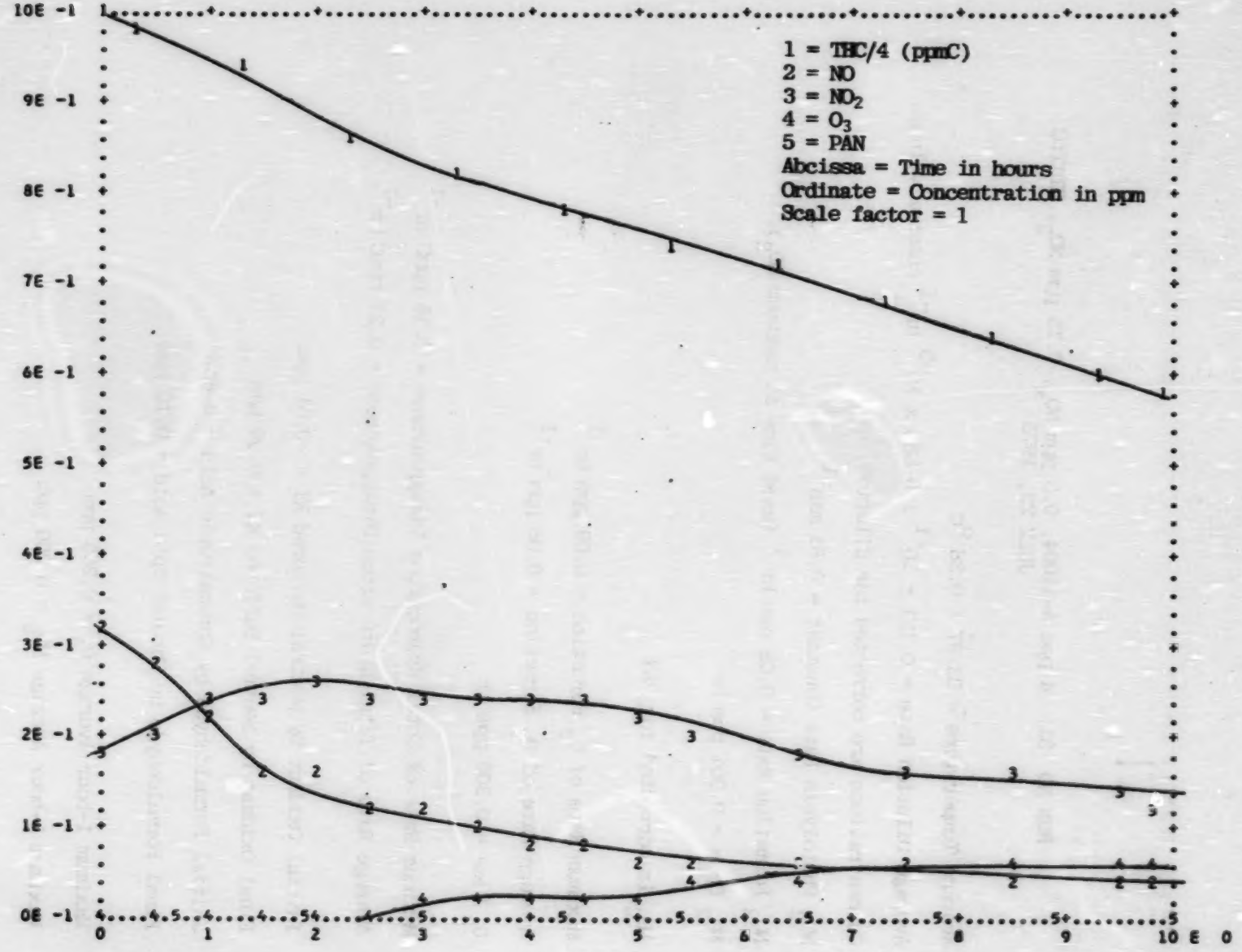
Final Oxidant by Neutral Buffered KI = 0.09 ppm

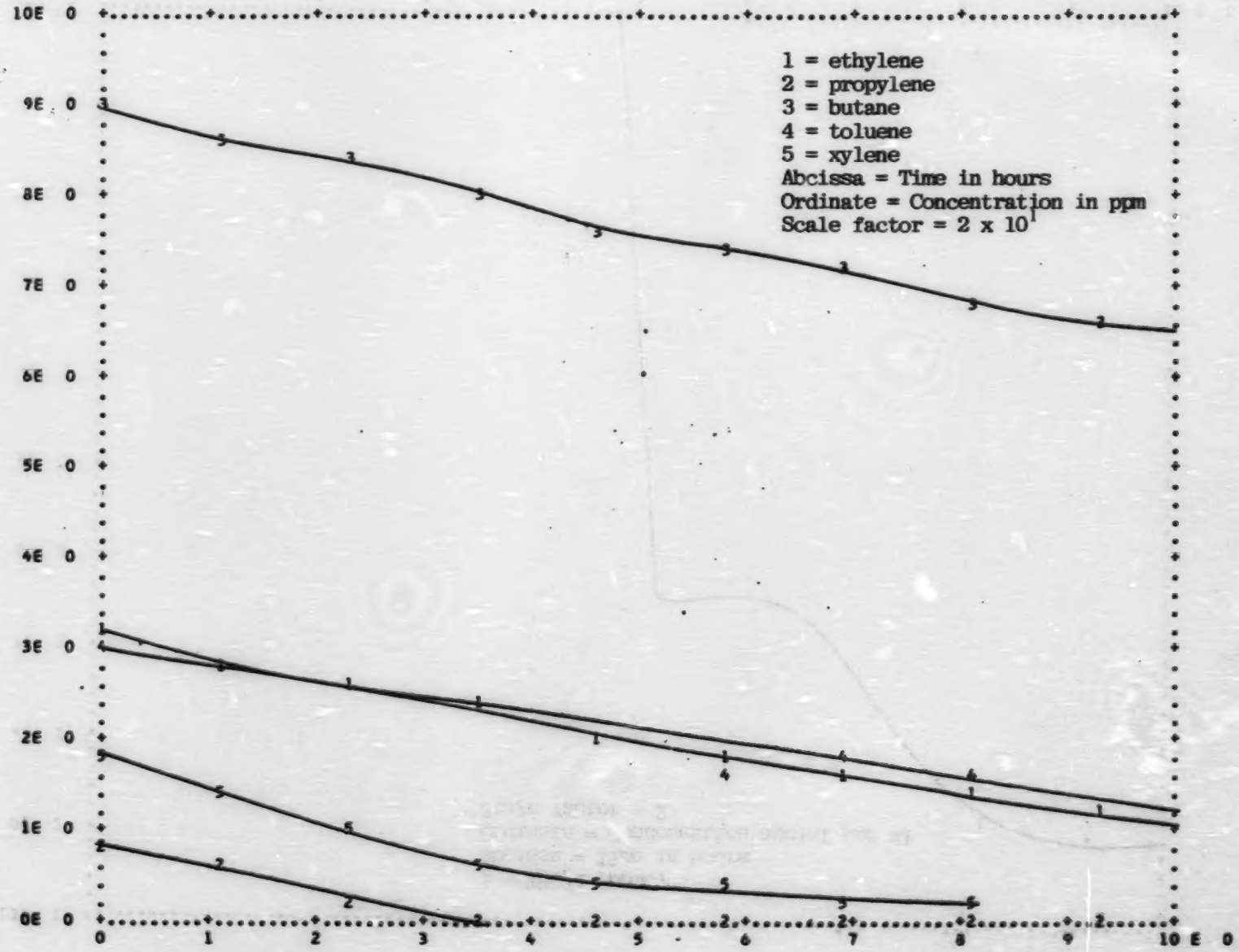
Initial Formaldehyde by Chromatropic Acid = 0 ppm

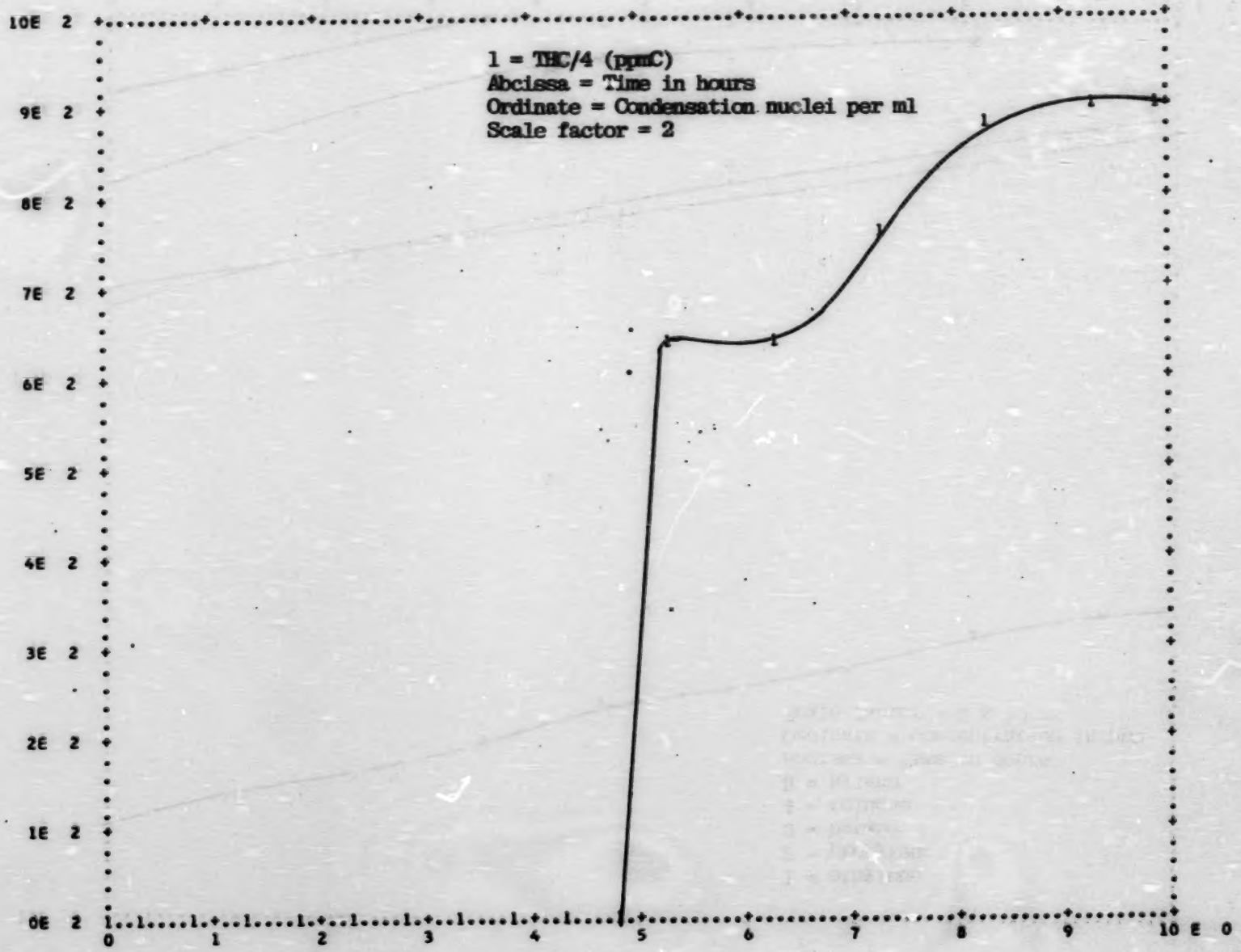
Final Formaldehyde by Chromatropic Acid = 0.10 ppm

Maximum 1-hour Average O_3 = 0.265 ppm

Maximum 1-hour Average NO_2 = 0.260 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = ethylene
2 = propylene
3 = butane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10^1
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 2
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0 1 2 3 4 5 6 7 8 9 10 E 0

RUN NO. 6R: 4 ppm XL-228, 0.5 ppm NO_x, DILUTION
MAY 15, 1975

Average Temperature = 32.76 ± 0.09 °C

Average Dilution Rate = $0.638 \times 10^{-1} \pm 0.999 \times 10^{-2}$ hr^{-1} chamber volumes

NO_2 Photolysis Rate Constant = 1.02 min^{-1}

NO_2 Formation Rate = 0.18 ppm hr^{-1} (used time at maximum NO_2).

NO_2 Dose = 1.229 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.11 ppm hr^{-1}

Average Rate of O_3 Formation = 0.08 ppm hr^{-1}

O_3 Dose = 1.487 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.40 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 0.62 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = 0.01 ppm

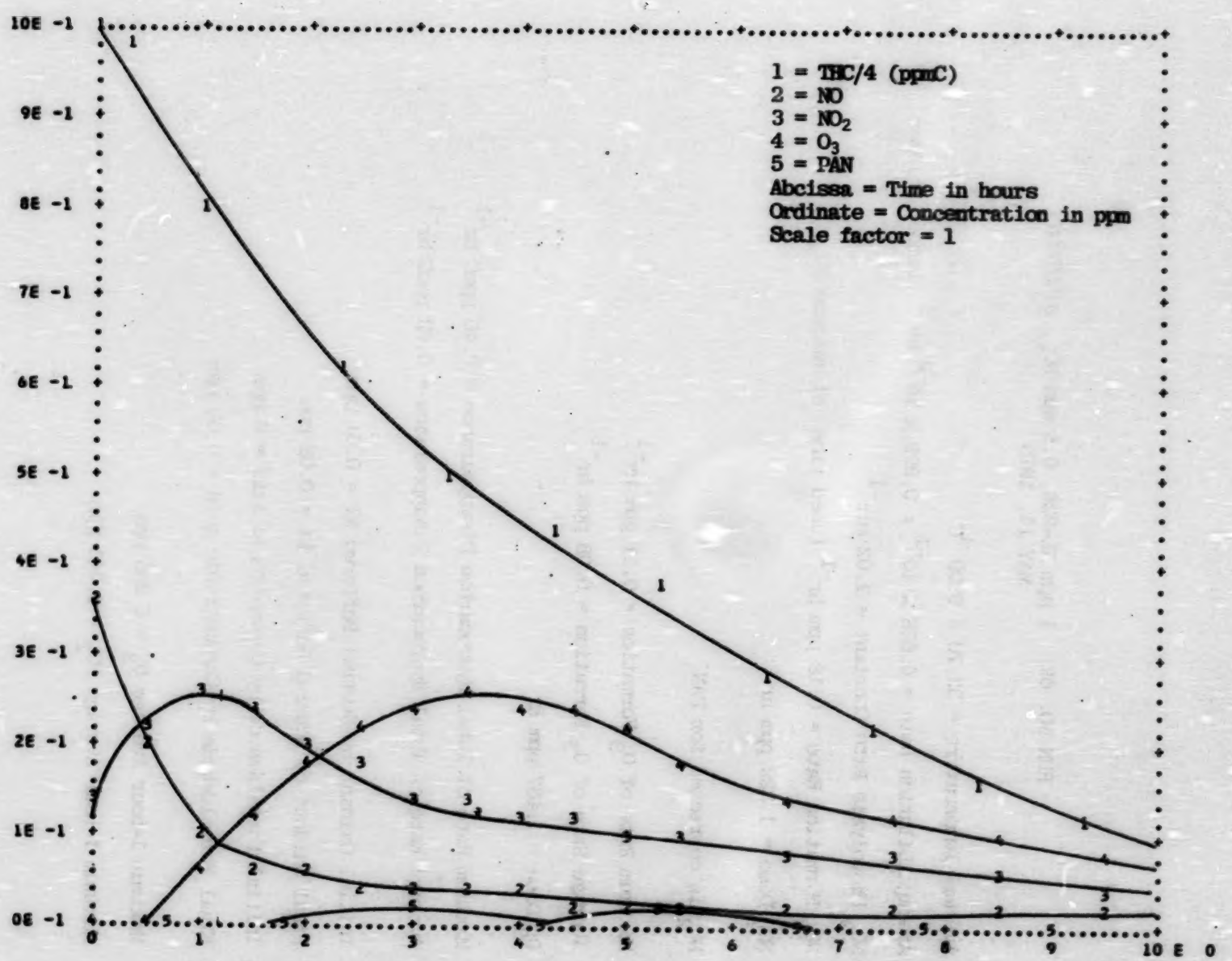
Final Oxidant by Neutral Buffered KI = 0.08 ppm

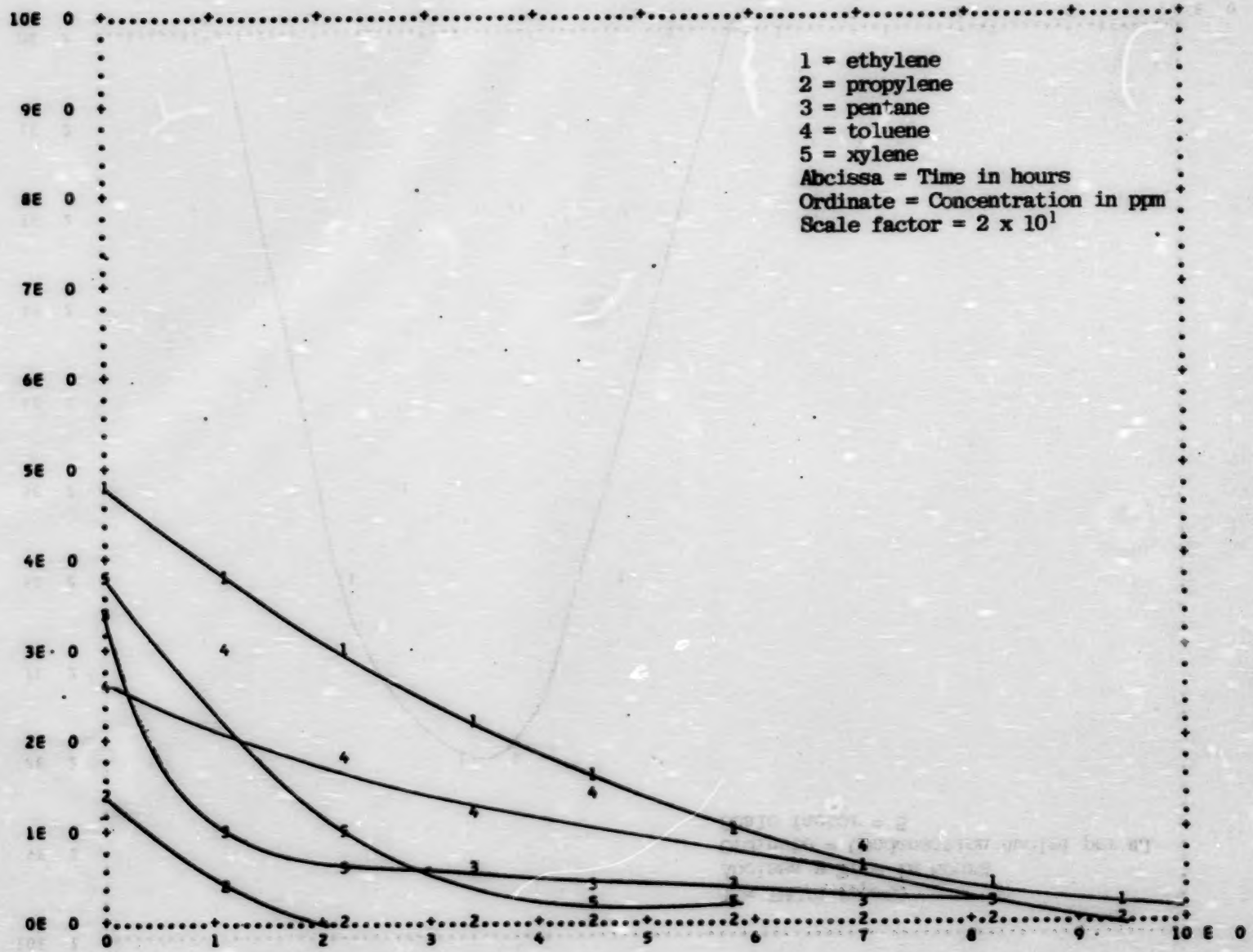
Initial Formaldehyde by Chromatropic Acid = 0 ppm

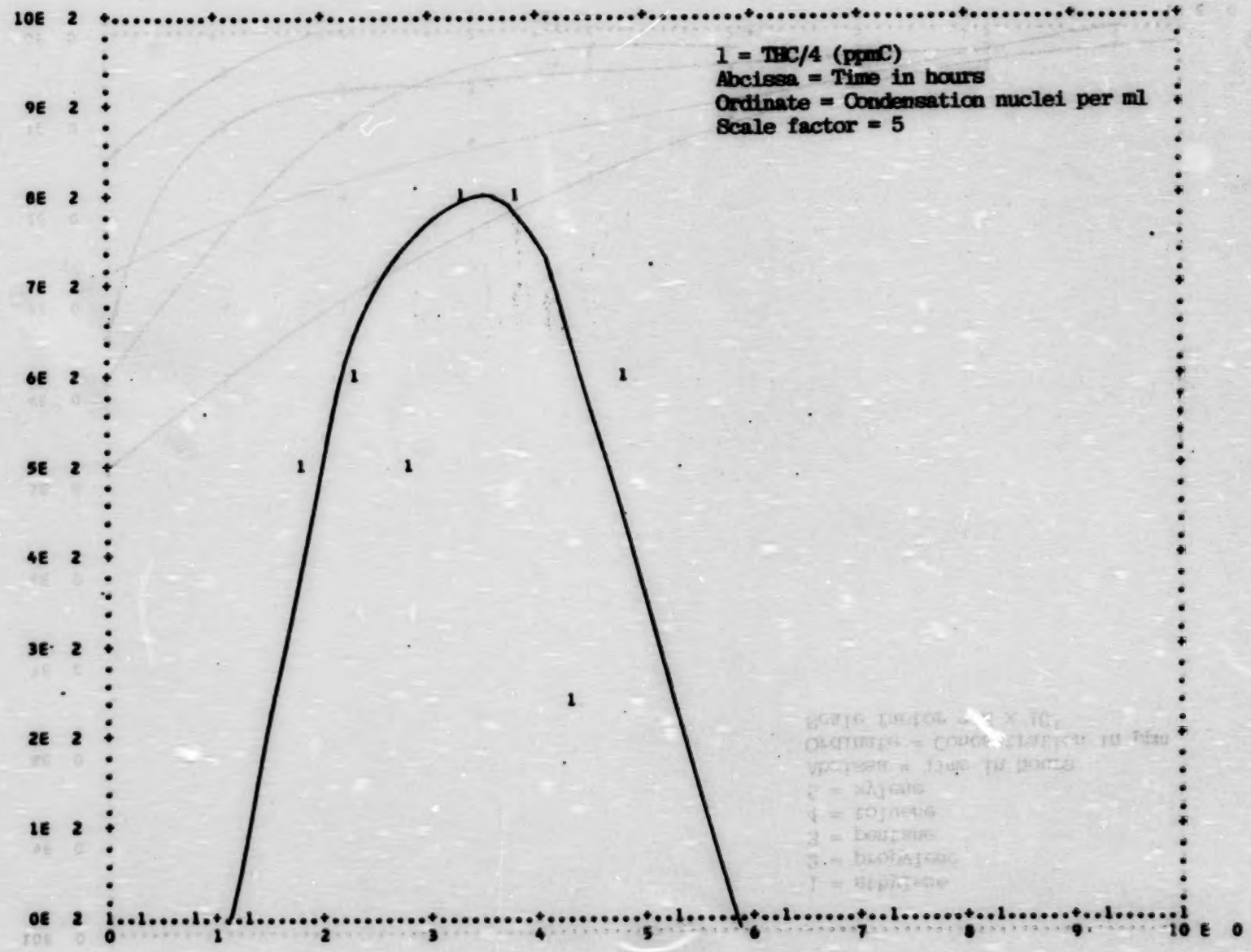
Final Formaldehyde by Chromatropic Acid = 0.09 ppm

Maximum 1-hour Average O_3 = 0.255 ppm

Maximum 1-hour Average NO_2 = 0.245 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0
1
2
3
4
5
6
7
8
9
10 E 0


1 = ethylene
2 = propylene
3 = pentane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10[1]
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 5
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0
1
2
3
4
5
6
7
8
9
10 E 0

RUN NO. 13: 4 ppm XL-228, 0.5 ppm NO_x, 0.15 ppm NO_2, DILUTION
JUNE 4, 1975

Average Temperature = 32.90 ± 0.05 °C

Average Dilution Rate = $0.578 \times 10^{-1} \pm 0.142 \times 10^{-1}$ hr^{-1} chamber volumes

NO_2 Photolysis Rate Constant = 0.9 min^{-1}

NO_2 Formation Rate = 0.18 ppm hr^{-1} (used maximum NO_2 value for time).

NO_2 Dose = 1.288 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.13 ppm hr^{-1}

Average Rate of O_3 Formation = 0.09 ppm hr^{-1}

O_3 Dose = 1.653 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.39 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 0.67 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = <0.01 ppm

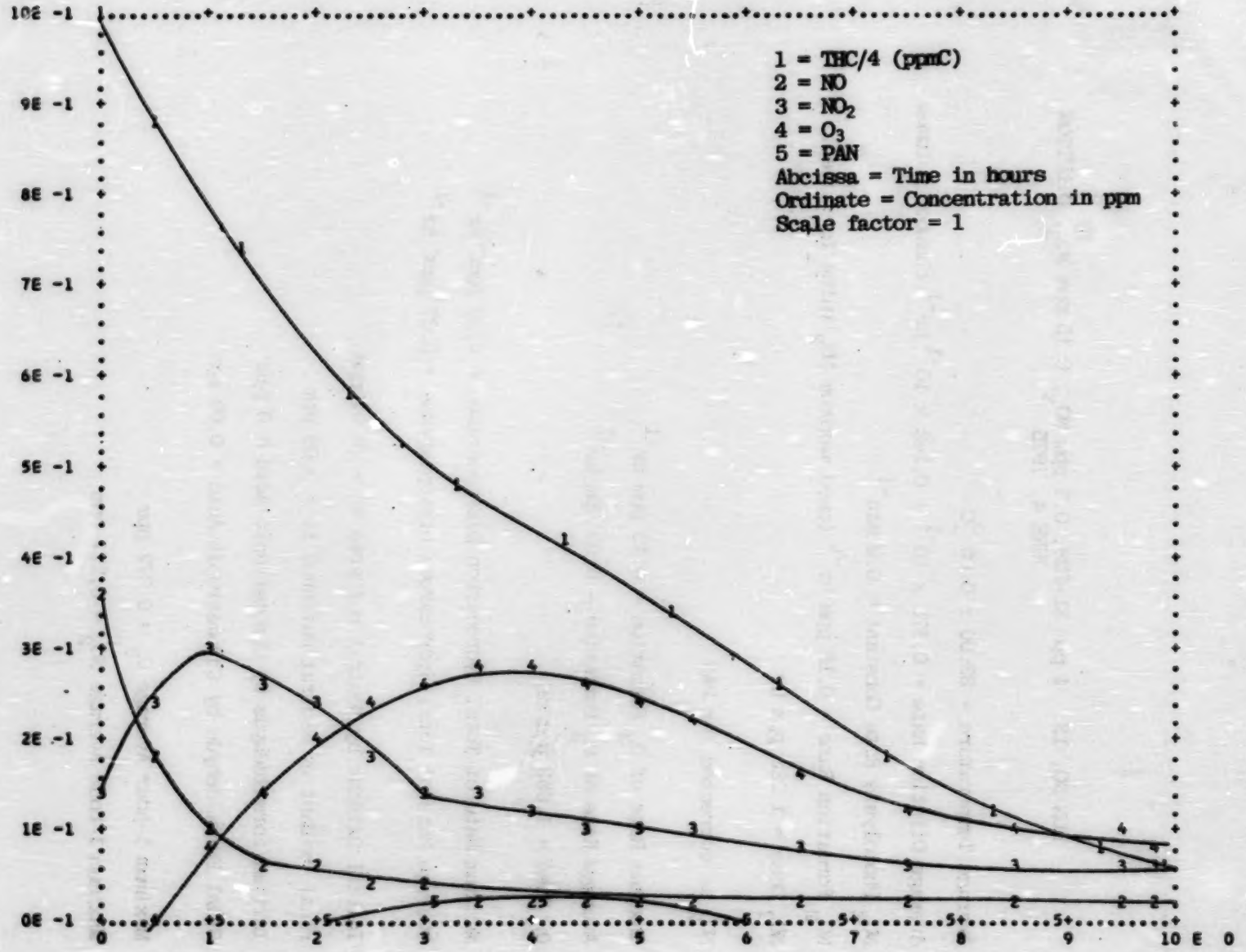
Final Oxidant by Neutral Buffered KI = 0.09 ppm

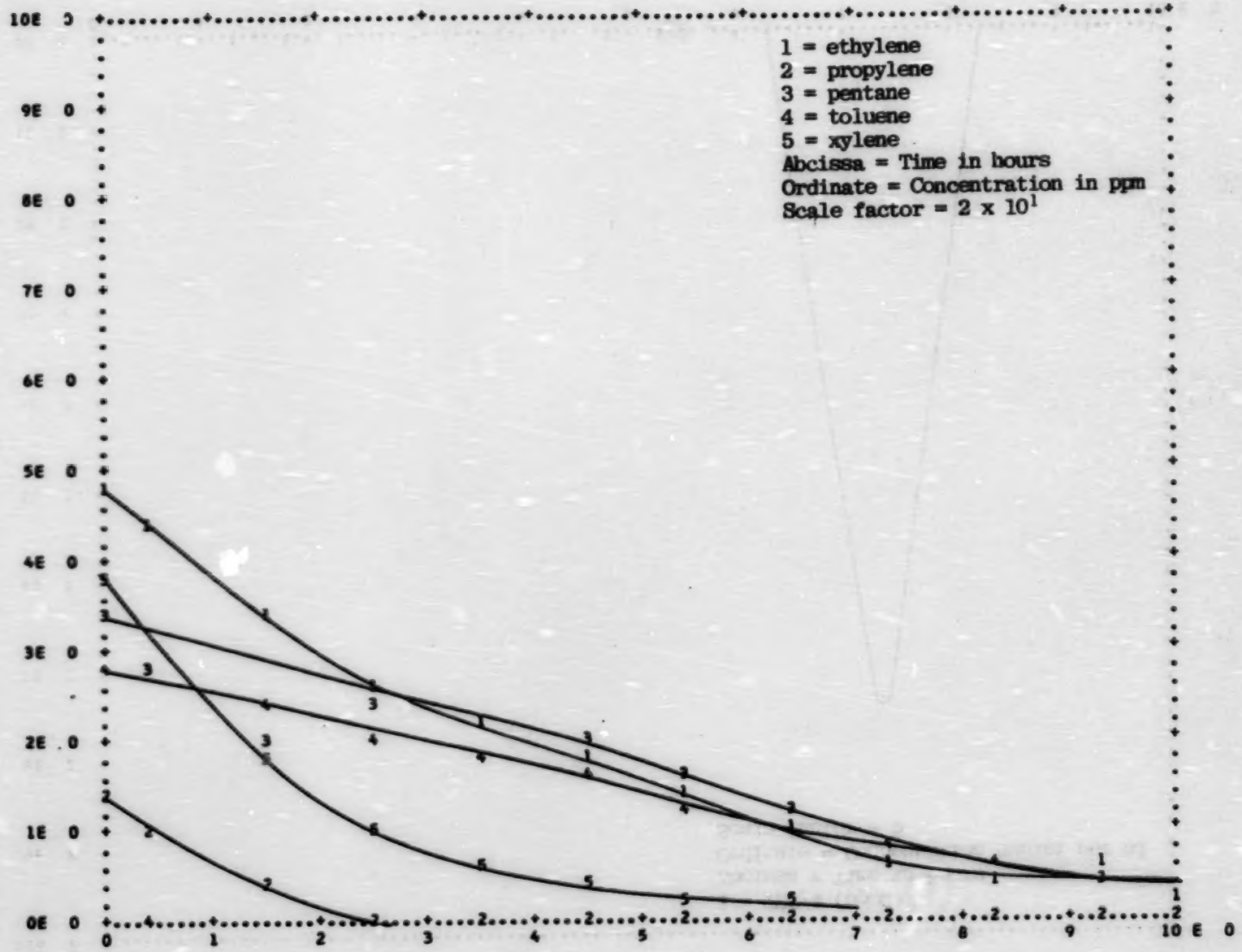
Initial Formaldehyde by Chromatropic Acid = 0 ppm

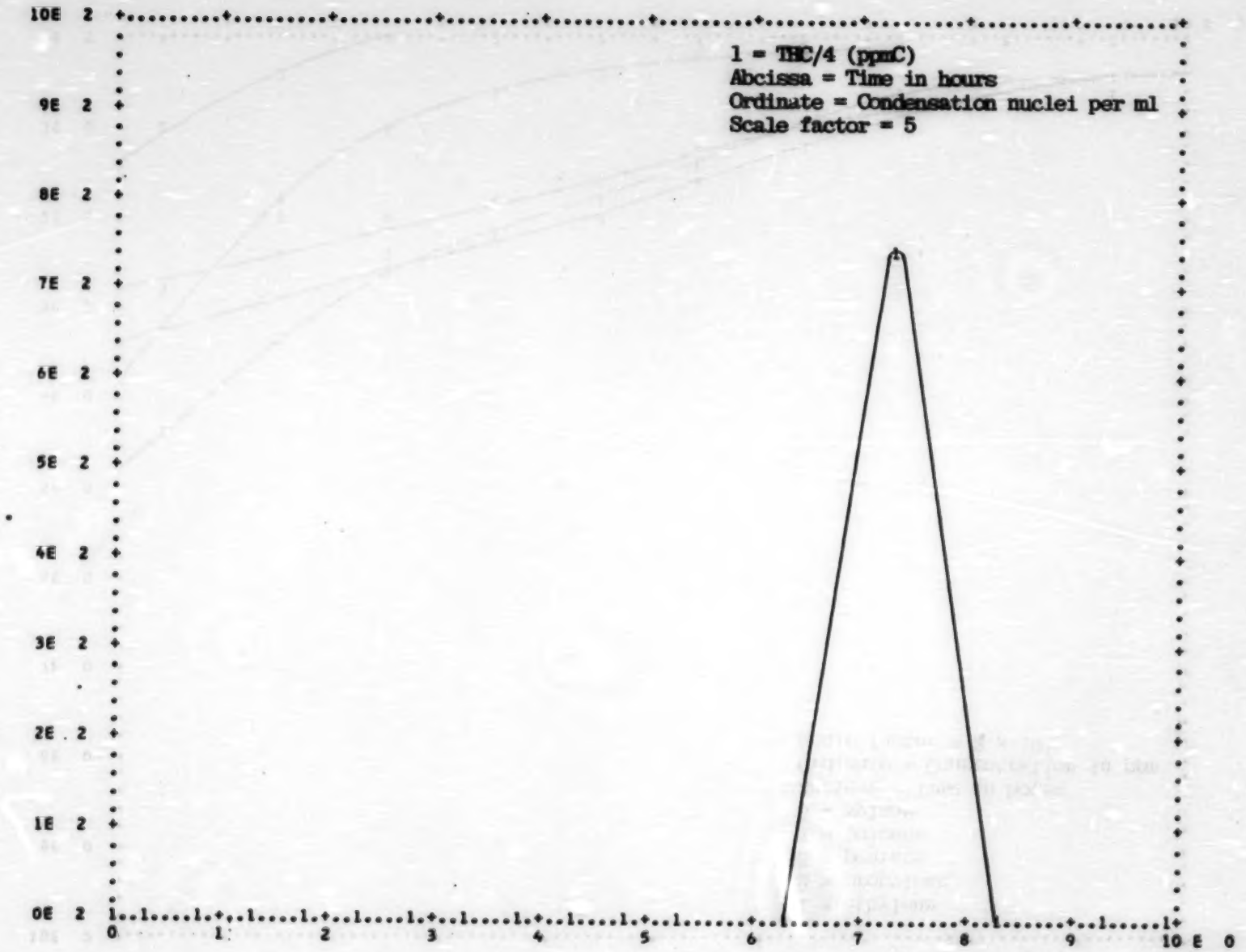
Final Formaldehyde by Chromatropic Acid = 0.09 ppm

Maximum 1-hour Average O_3 = 0.272 ppm

Maximum 1-hour Average NO_2 = 0.277 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = ethylene
2 = propylene
3 = pentane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10[1]
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 5
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0 1 2 3 4 5 6 7 8 9 10 E 0

RUN NO. 25: 4 ppm A-11004, 0.5 ppm NO_x, 0.15 ppm NO_2, DILUTION
JULY 7, 1975

Average Temperature = 32.70 ± 0.18 °C

Average Dilution Rate = $0.529 \times 10^{-1} \pm 0.133 \times 10^{-1}$ hr^{-1} chamber volumes

NO_2 Photolysis Rate Constant = 0.65 min^{-1}

NO_2 Formation Rate = 0.09 ppm hr^{-1} (used time at maximum NO_2).

NO_2 Dose = 1.484 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.04 ppm hr^{-1}

Average Rate of O_3 Formation = 0.03 ppm hr^{-1}

O_3 Dose = 1.019 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.30 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 0.31 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = <0.01 ppm

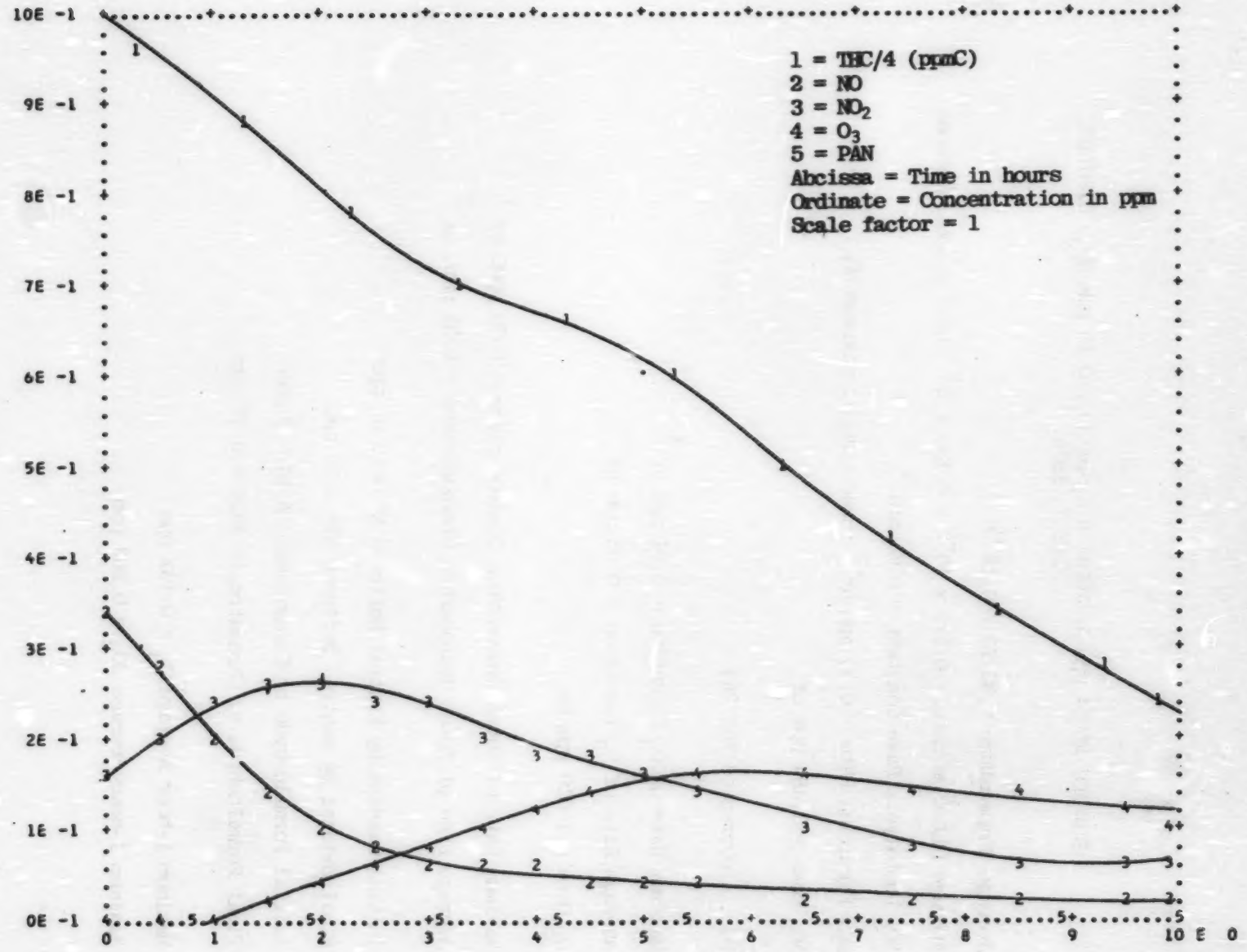
Final Oxidant by Neutral Buffered KI= 0.10 ppm

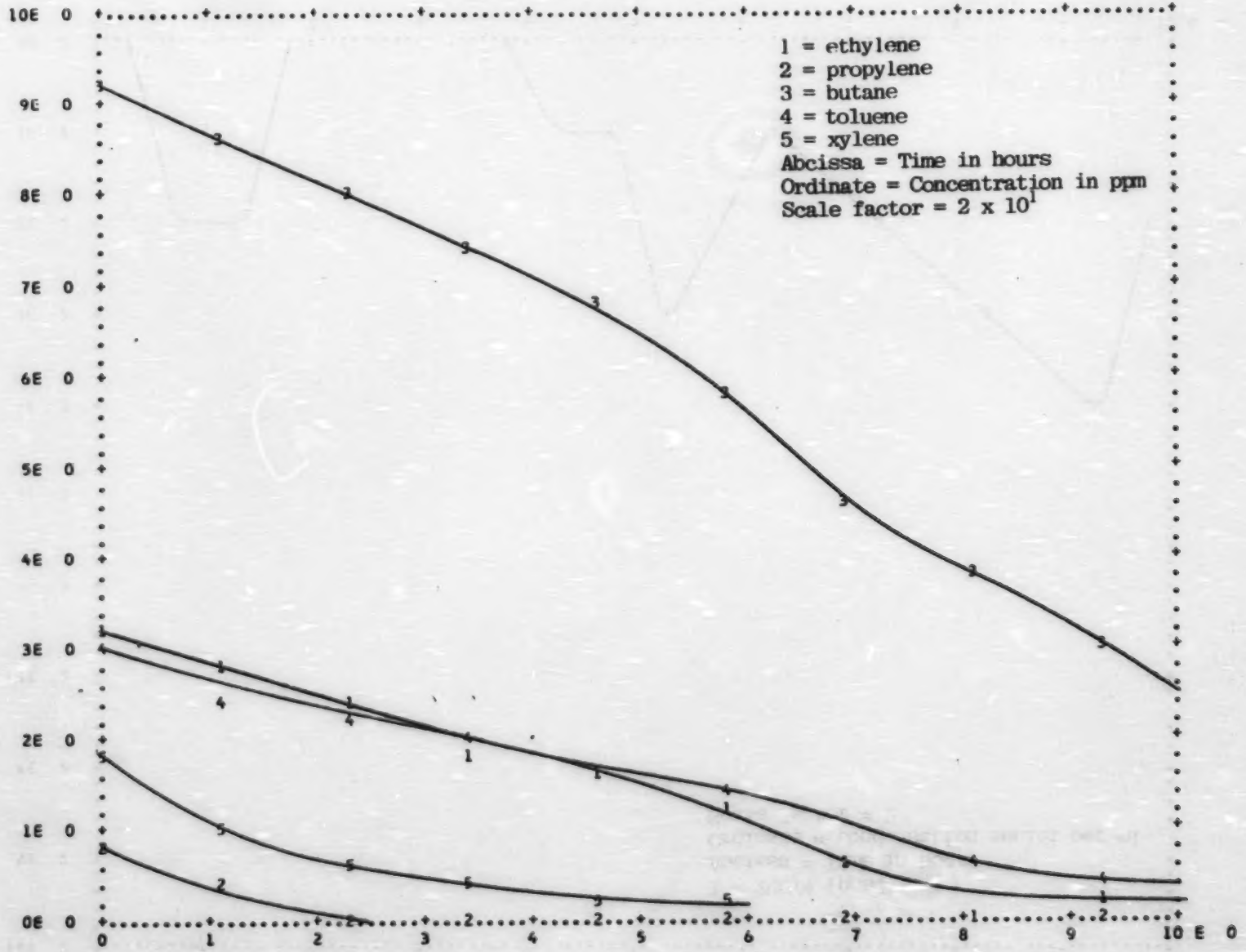
Initial Formaldehyde by Chromatropic Acid = 0 ppm

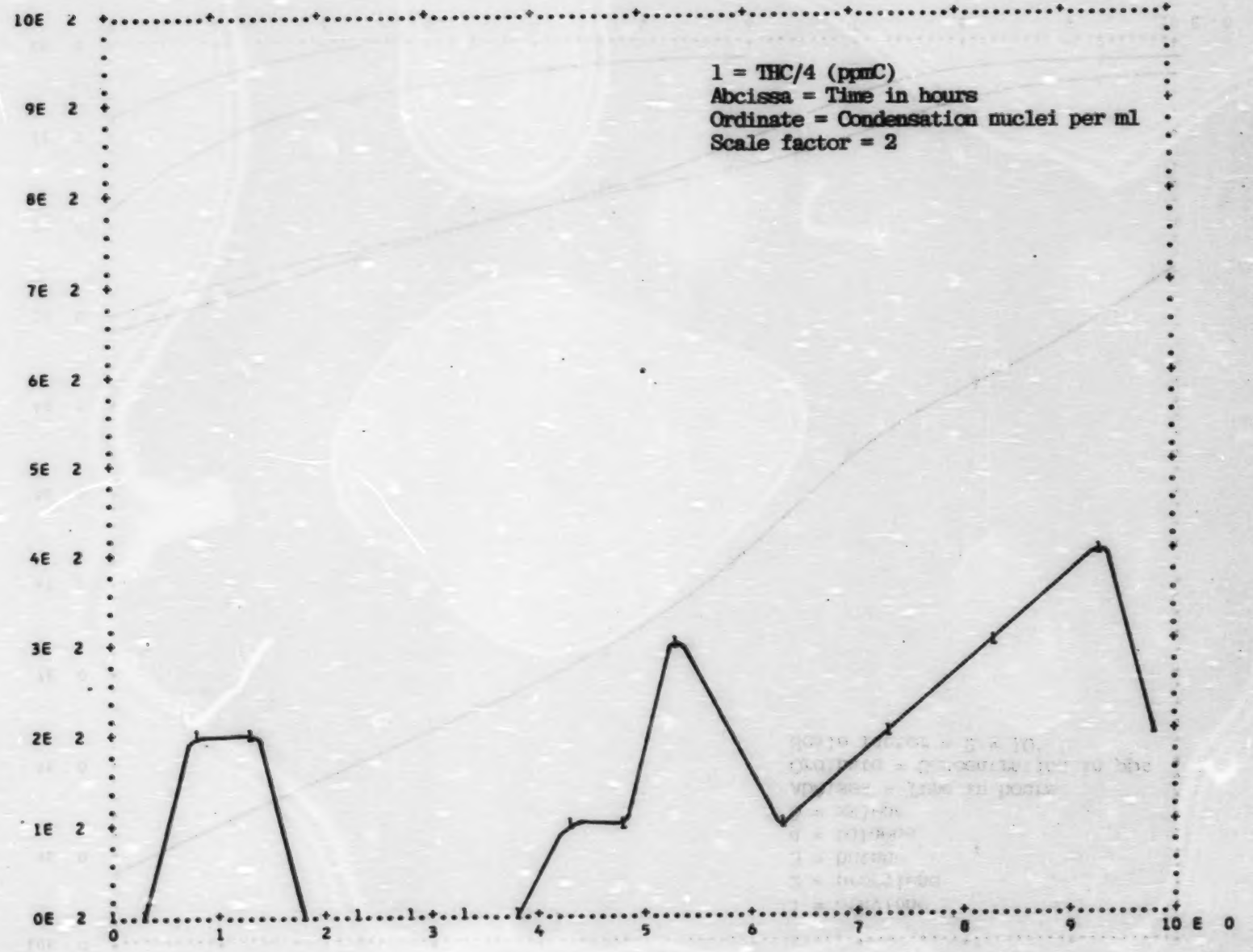
Final Formaldehyde by Chromatropic Acid = 0.07 ppm

Maximum 1-hour Average O_3 = 0.162 ppm

Maximum 1-hour Average NO_2 = 0.263 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = ethylene
2 = propylene
3 = butane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10^1
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 2
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0
1
2
3
4
5
6
7
8
9
10 E 0

RUN NO. 23: 4 ppm A-11004, 0.5 ppm NO_x, DILUTION
JUNE 30, 1975

Average Temperature = 32.68 ± 0.19 °C

Average Dilution Rate = $0.548 \times 10^{-1} \pm 0.135 \times 10^{-1}$ hr^{-1} chamber volumes

NO_2 Photolysis Rate Constant = 0.92 min^{-1}

NO_2 Formation Rate = 0.10 ppm hr^{-1} (used time at maximum NO_2).

NO_2 Dose = 1.607 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.05 ppm hr^{-1}

Average Rate of O_3 Formation = 0.03 ppm hr^{-1}

O_3 Dose = 1.052 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.33 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 0.35 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = <0.01 ppm

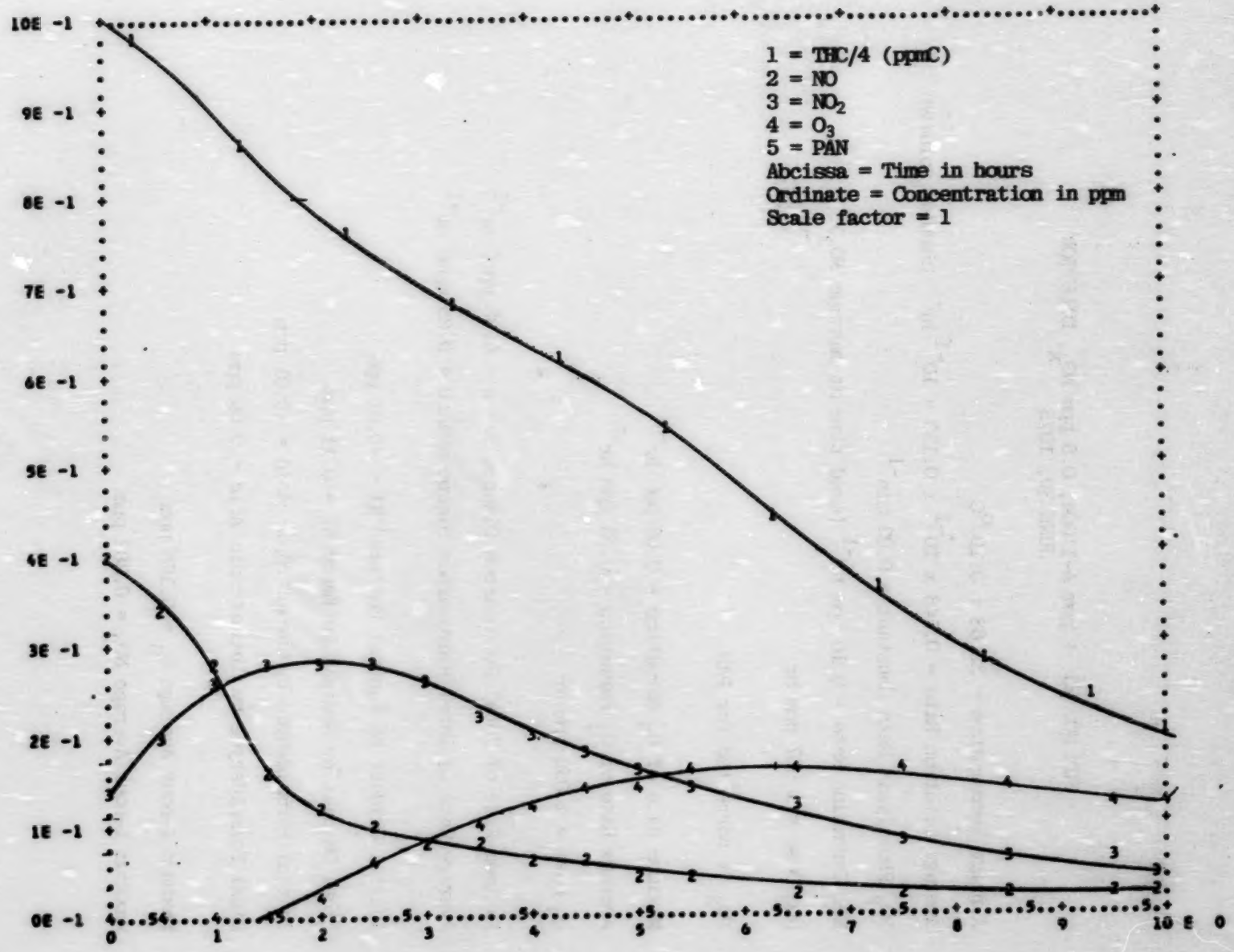
Final Oxidant by Neutral Buffered KI = 0.11 ppm

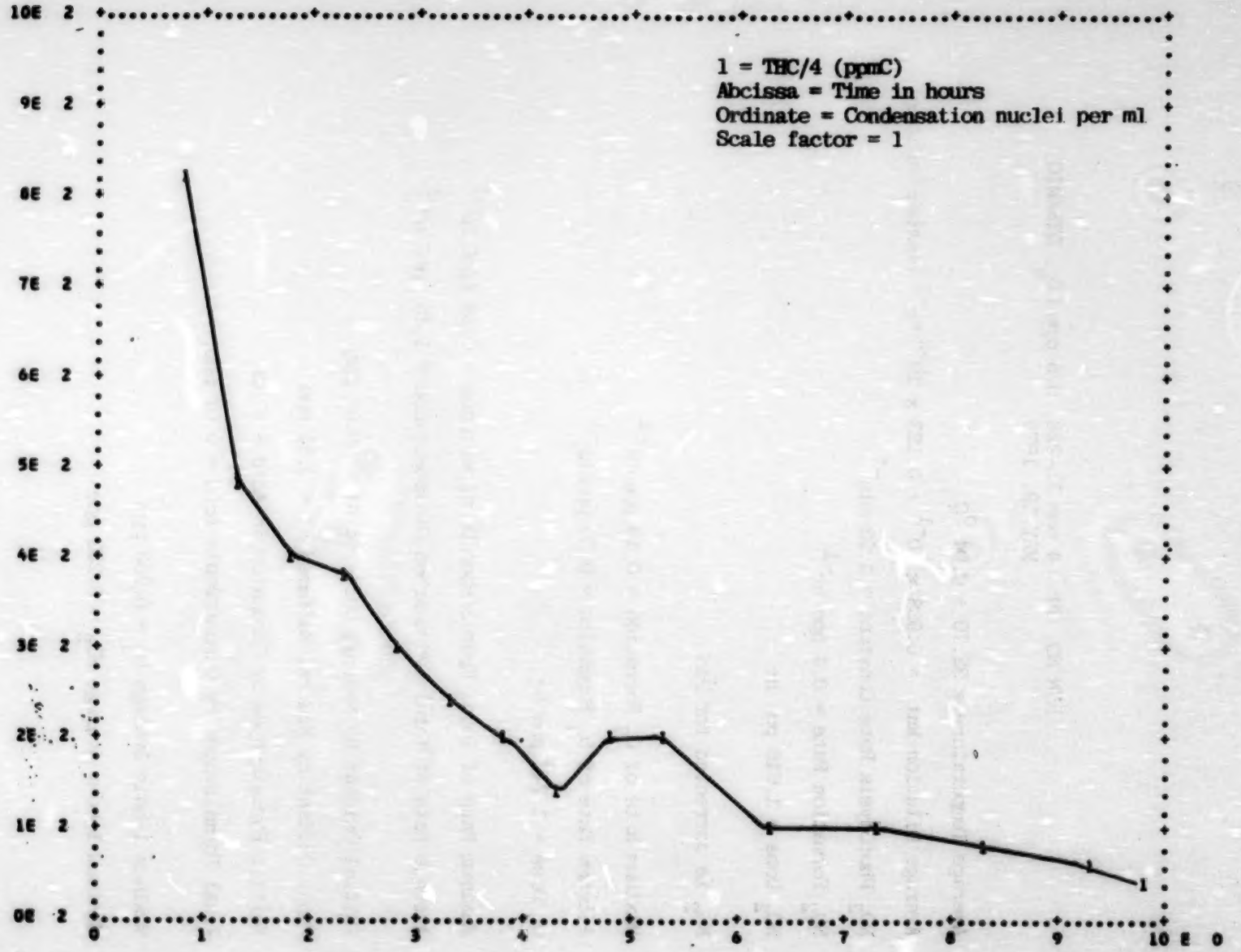
Initial Formaldehyde by Chromatropic Acid = <0.01 ppm

Final Formaldehyde by Chromatropic Acid = 0.08 ppm

Maximum 1-hour Average O_3 = 0.165 ppm

Maximum 1-hour Average NO_2 = 0.282 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0
1
2
3
4
5
6
7
8
9
10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 1
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0
1
2
3
4
5
6
7
8
9
10 E 0

RUN NO. 8R: 4 ppm XL-228, 0.5 ppm NO_x, DYNAMIC
MAY 19, 1975

Average Temperature = 32.70 ± 0.04 °C

Average Dilution Rate = $0.938 \times 10^{-1} \pm 0.123 \times 10^{-2}$ hr^{-1} chamber volumes

NO_2 Photolysis Rate Constant = 1.23 min^{-1}

NO_2 Formation Rate = 0.4 ppm hr^{-1}

NO_2 Dose = 1.616 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.19 ppm hr^{-1}

Average Rate of O_3 Formation = 0.29 ppm hr^{-1}

O_3 Dose = 1.743 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.58 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 1.45 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = <0.01 ppm

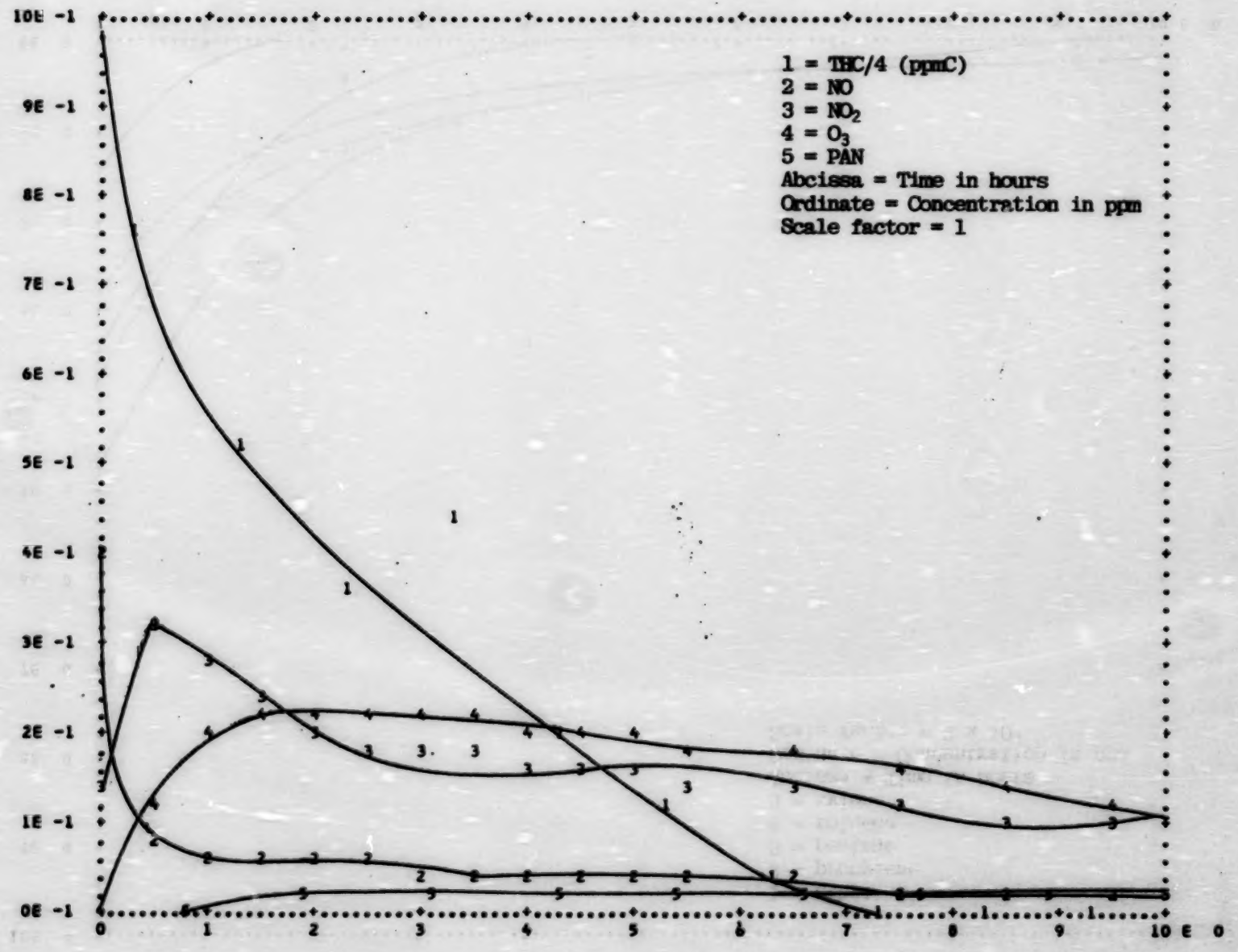
Final Oxidant by Neutral Buffered KI = 0.11 ppm

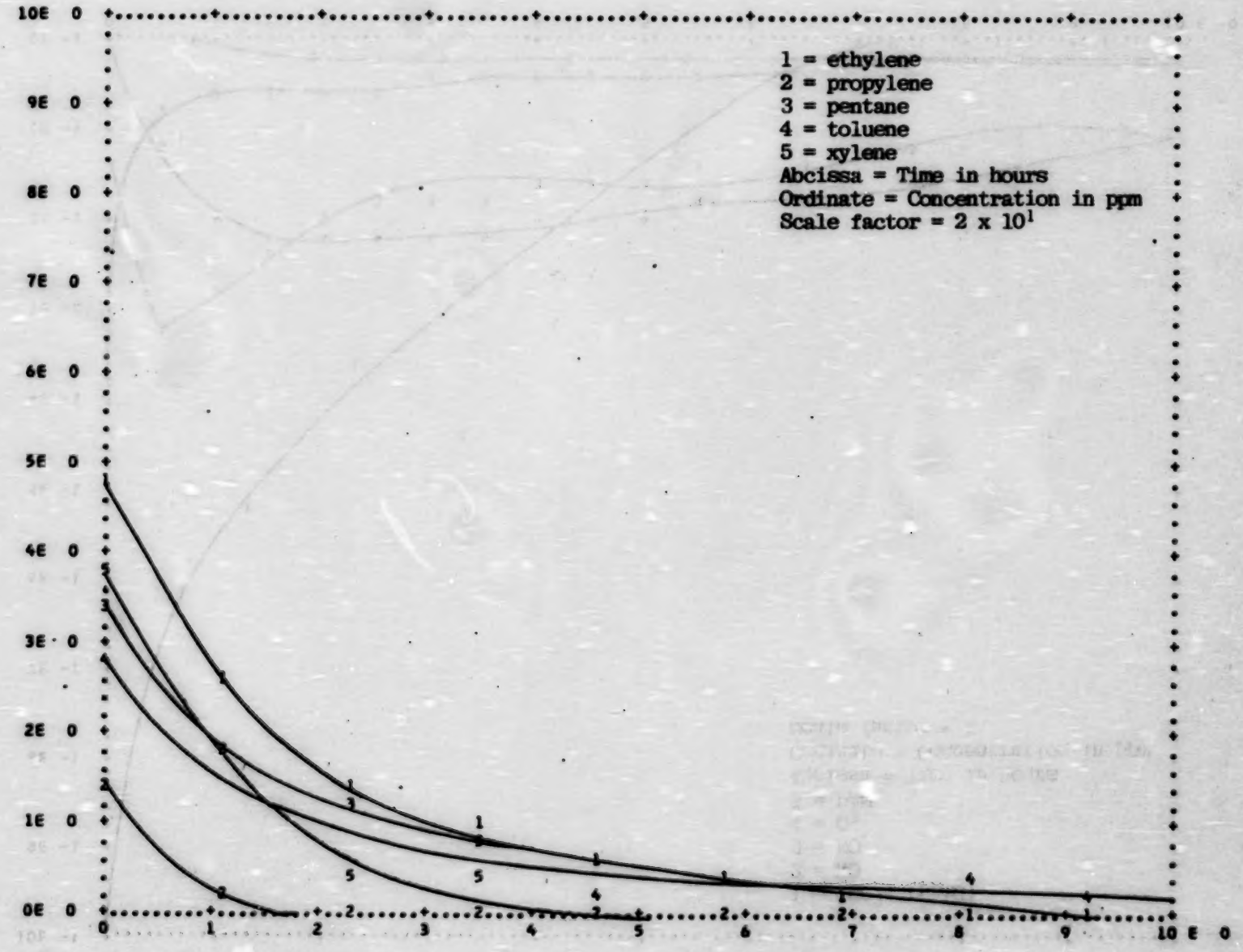
Initial Formaldehyde by Chromatropic Acid = 0 ppm

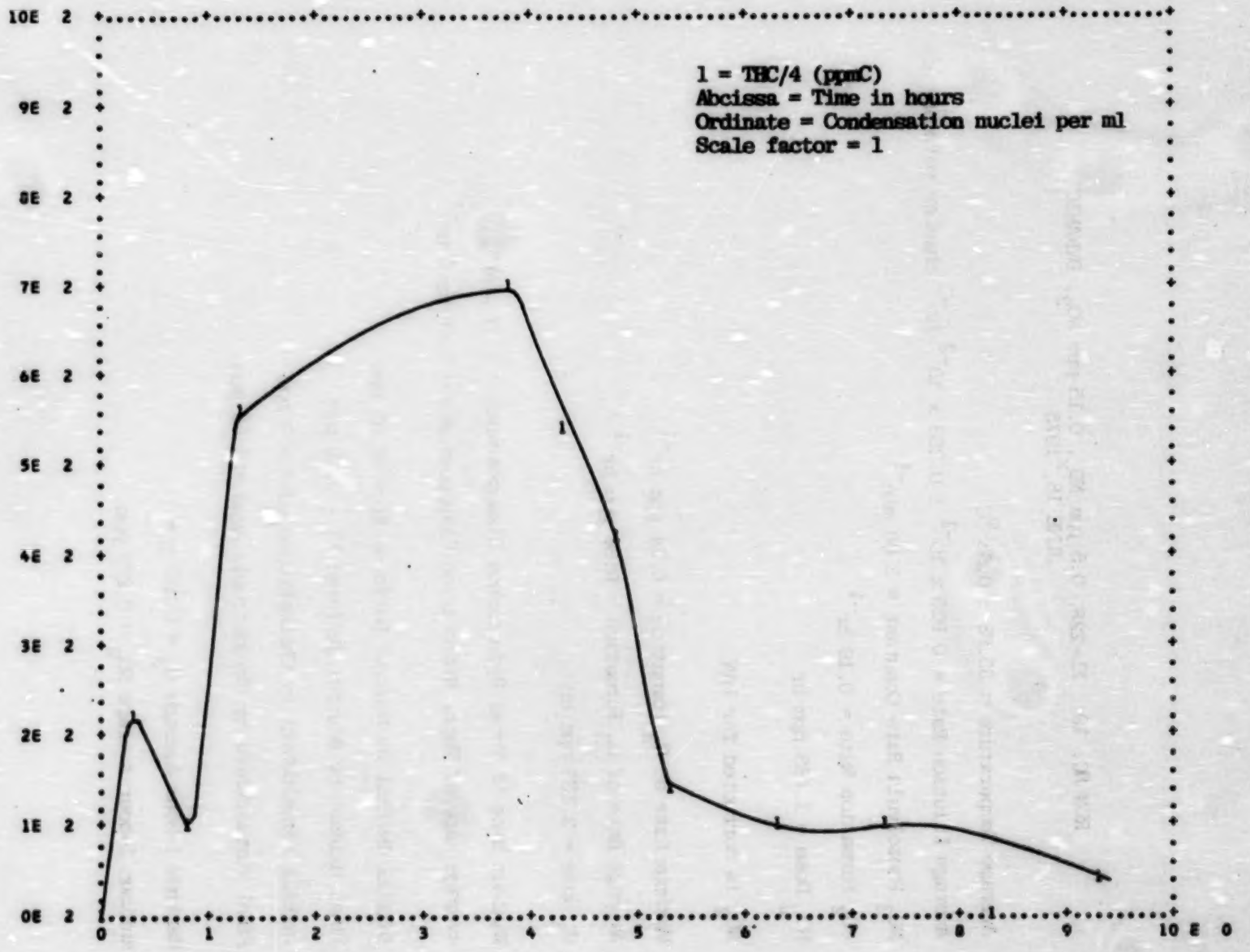
Final Formaldehyde by Chromatropic Acid = 0.07 ppm

Maximum 1-hour Average O_3 = 0.258 ppm

Maximum 1-hour Average NO_2 = 0.252 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = ethylene
2 = propylene
3 = pentane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10[1]
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 1
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0
1
2
3
4
5
6
7
8
9
10 E 0

RUN NO. 19: XL-228, 0.5 ppm NO_x, 0.15 ppm NO_2, DYNAMIC
JUNE 18, 1975

Average Temperature = 35.68 ± 0.68 °C

Average Dilution Rate = $0.925 \times 10^{-1} \pm 0.258 \times 10^{-2}$ hr^{-1} chamber volumes

NO_2 Photolysis Rate Constant = 3.80 min^{-1}

NO_2 Formation Rate = 0.19 hr^{-1}

NO_2 Dose = 1.483 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.24 ppm hr^{-1}

Average Rate of O_3 Formation = 0.36 ppm hr^{-1}

O_3 Dose = 2.135 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.57 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 1.46 ppmC hr^{-1}

Initial Oxidant By Neutral Buffered KI = <0.01 ppm

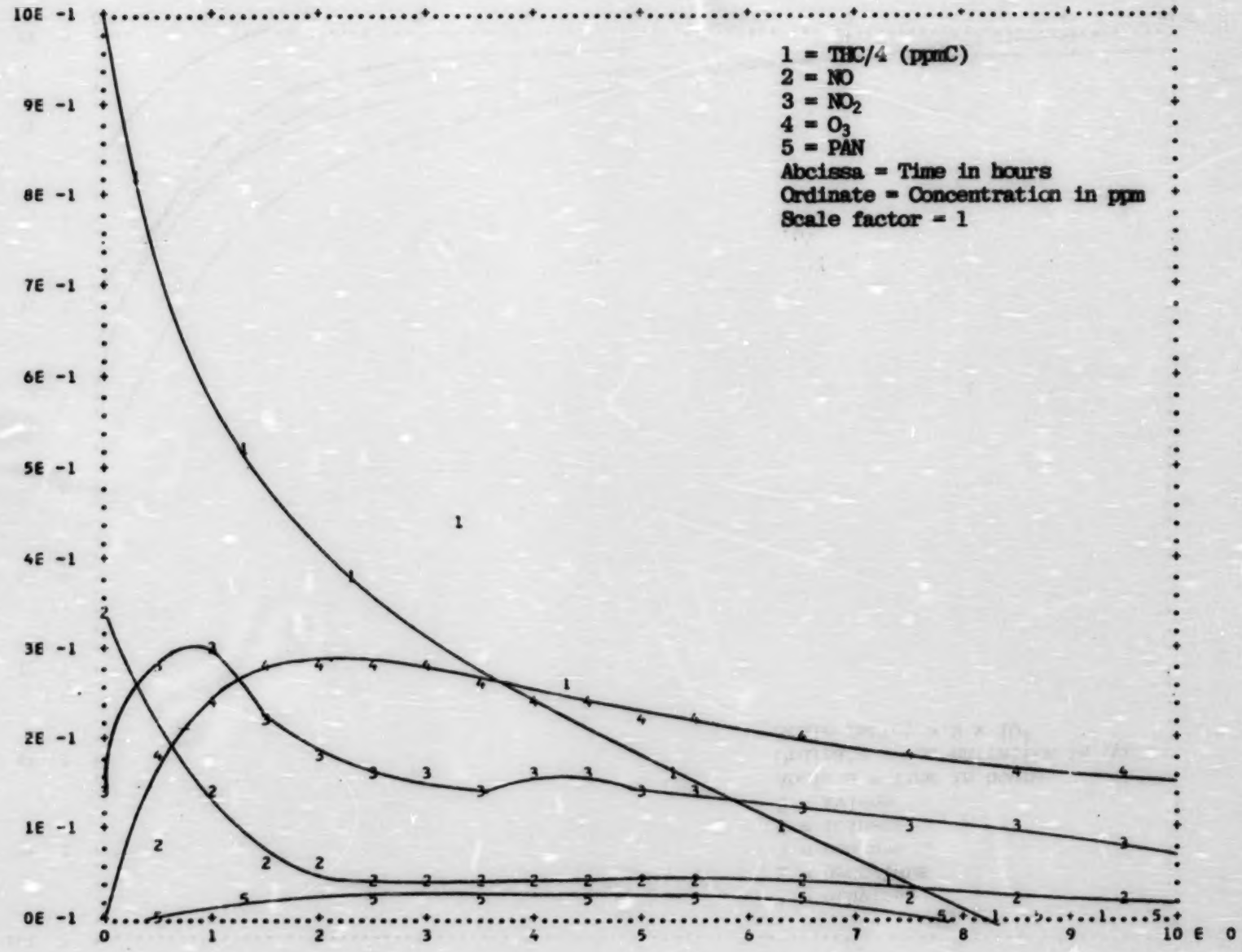
Final Oxidant by Neutral Buffered KI = 0.10 ppm

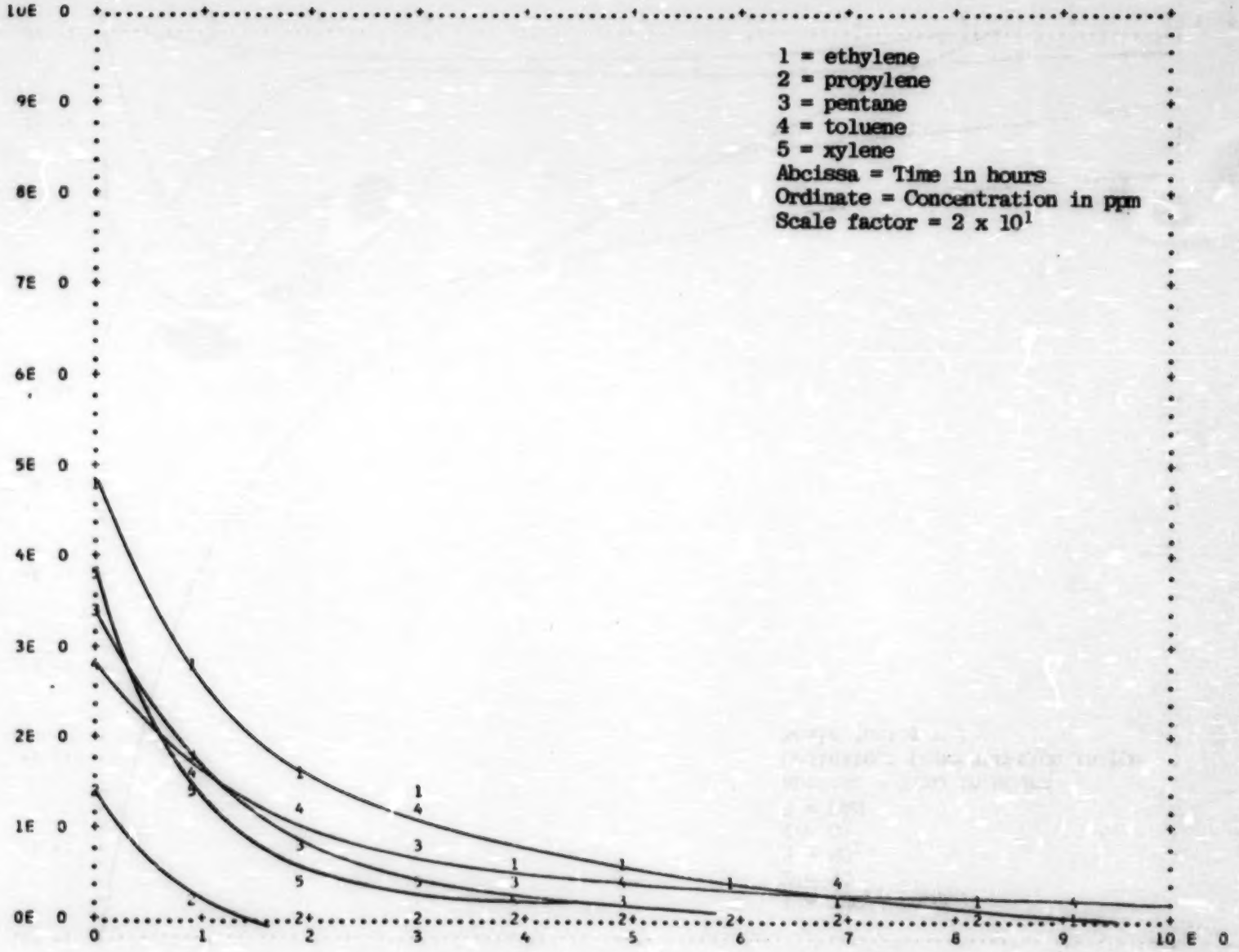
Initial Formaldehyde by Chromatropic Acid = 0 ppm

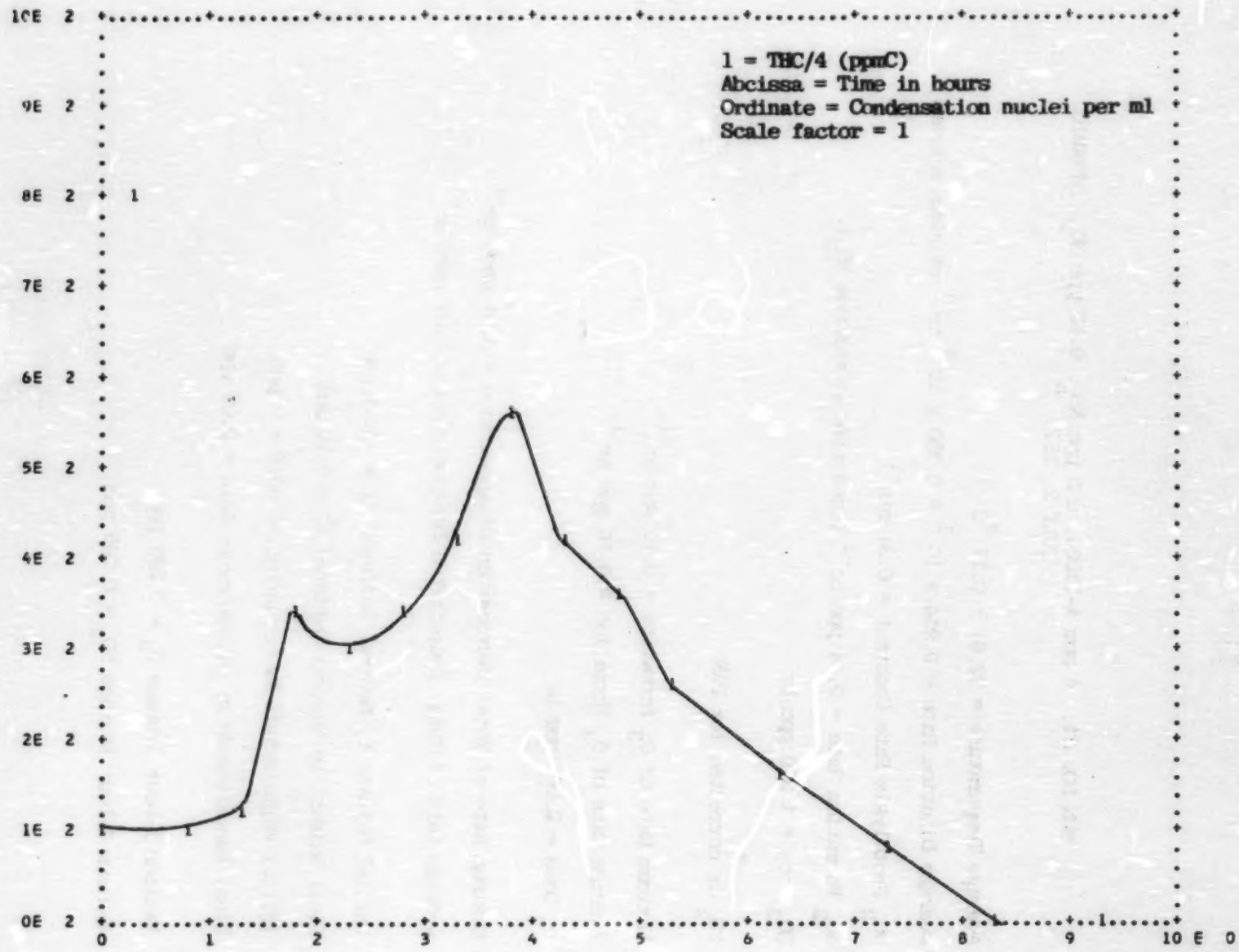
Final Formaldehyde by Chromatropic Acid = 0.06 ppm

Maximum 1-hour Average O_3 = 0.287 ppm

Maximum 1-hour Average NO_2 = 0.273 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = ethylene
2 = propylene
3 = pentane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10[1]
1UE 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 1
1CE 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0 1 2 3 4 5 6 7 8 9 10 E 0

RUN NO. 24: 4 ppm A-11004, 0.5 ppm NO_x, 0.15 ppm NO_2, DYNAMIC
JULY 2, 1975

Average Temperature = 32.61 ± 0.17 °C

Average Dilution Rate = $0.914 \times 10^{-1} \pm 0.350 \times 10^{-2}$ hr^{-1} chamber volumes

NO_2 Photolysis Rate Constant = 0.84 min^{-1}

NO_2 Formation Rate = 0.34 ppm hr^{-1} (used time at maximum NO_2).

NO_2 Dose = 1.370 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.10 ppm hr^{-1}

Average Rate of O_3 Formation = 0.10 ppm hr^{-1}

O_3 Dose = 2.061 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.51 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 0.87 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = <0.01 ppm

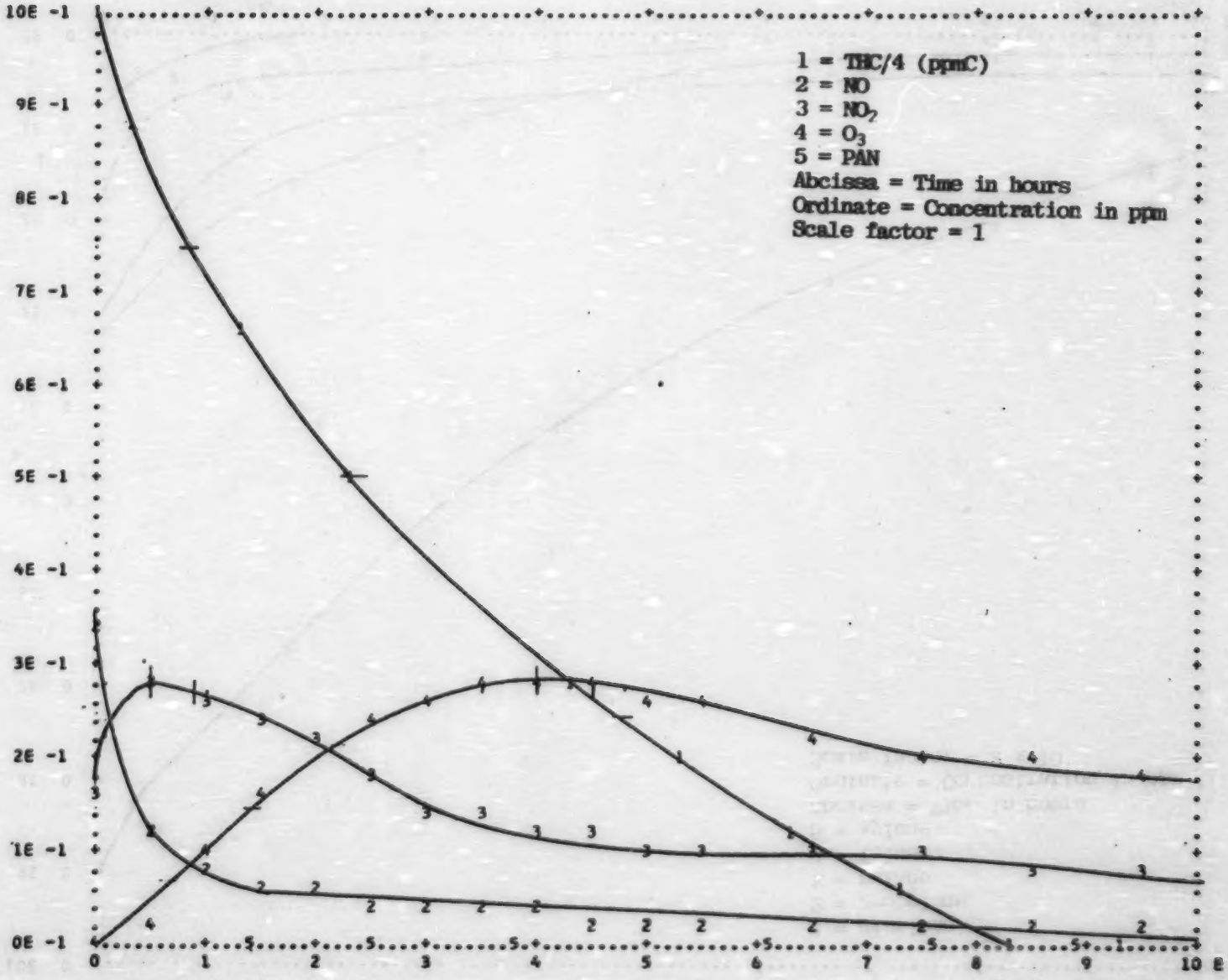
Final Oxidant by Neutral Buffered KI = 0.16 ppm

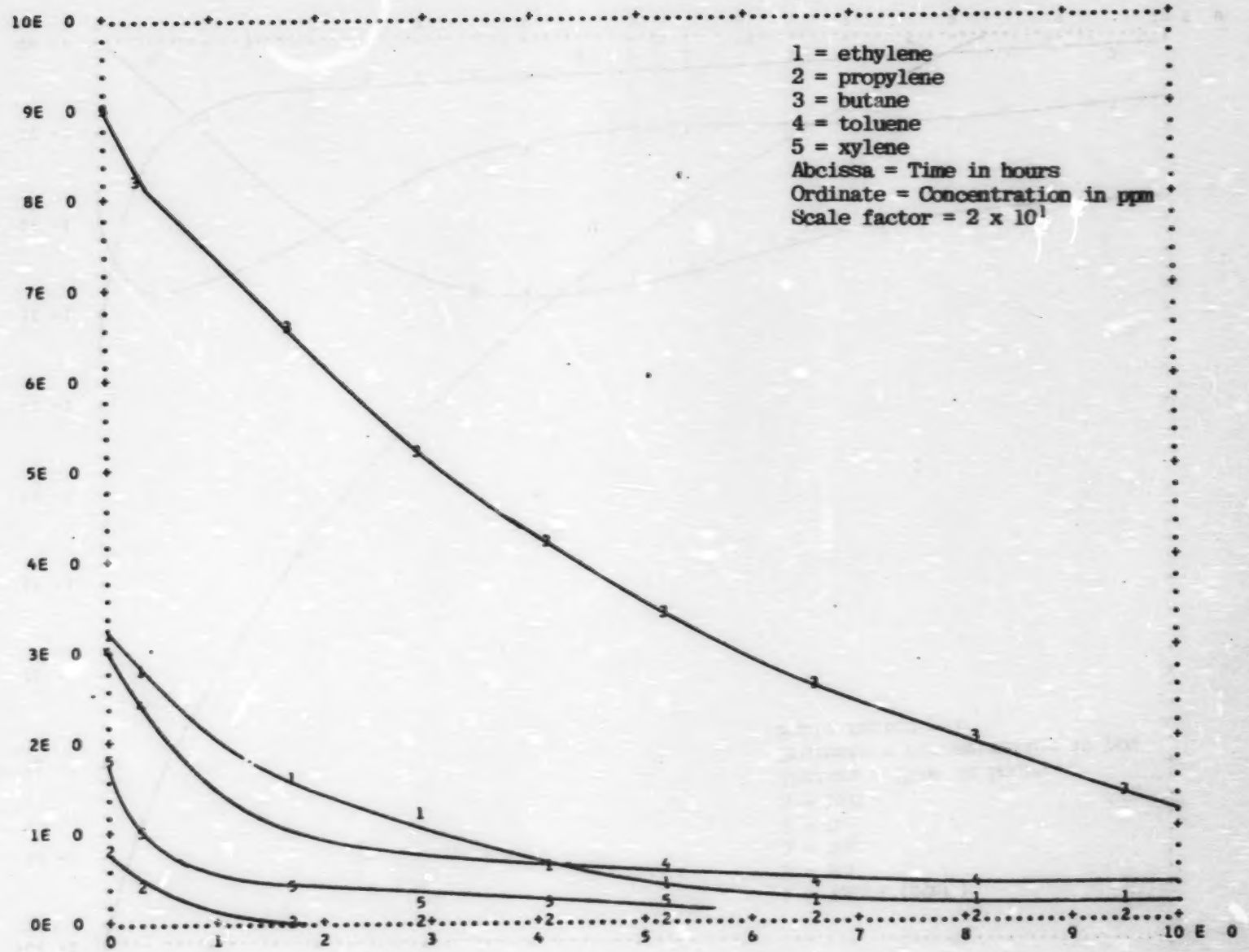
Initial Formaldehyde by Chromatropic Acid = 0 ppm

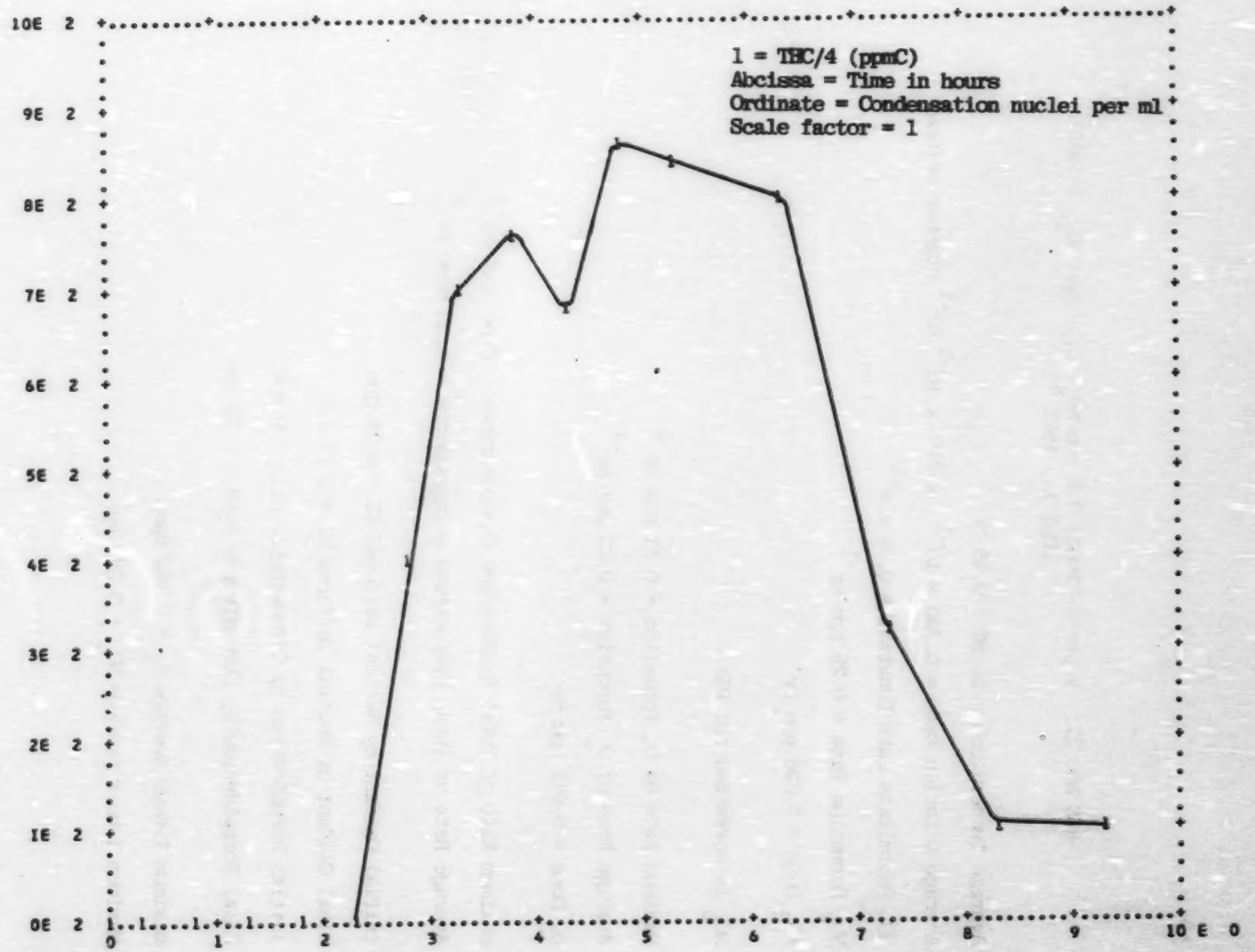
Final Formaldehyde by Chromatropic Acid = 0.09 ppm

Maximum 1-hour Average O_3 = 0.283 ppm

Maximum 1-hour Average NO_2 = 0.265 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO_2
4 = O_3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = ethylene
2 = propylene
3 = butane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10¹
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0 1 2 3 4 5 6 7 8 9 10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 1
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0
1
2
3
4
5
6
7
8
9
10 E 0

RUN NO. 27: 4 ppm A-11004, 0.5 ppm NO_x, 0.15 ppm NO_2, DYNAMIC
JULY 14, 1975

Average Temperature = 33.86 ± 0.35 °C

Average Dilution Rate = $0.930 \times 10^{-1} \pm 0.510 \times 10^{-3}$ hr^{-1} chamber volumes

NO_2 Photolysis Rate Constant = 0.98 min^{-1}

NO_2 Formation Rate = 0.29 ppm hr^{-1}

NO_2 Dose = 1.826 ppm hr

NO_2 is corrected for PAN

Maximum Rate of O_3 Formation = 0.11 ppm hr^{-1}

Average Rate of O_3 Formation = 0.21 ppm hr^{-1}

O_3 Dose = 0.972 ppm hr

Maximum Rate of Total Hydrocarbon Disappearance = 0.56 ppmC hr^{-1}

Average Rate of Total Hydrocarbon Disappearance = 1.53 ppmC hr^{-1}

Initial Oxidant by Neutral Buffered KI = 0.01 ppm

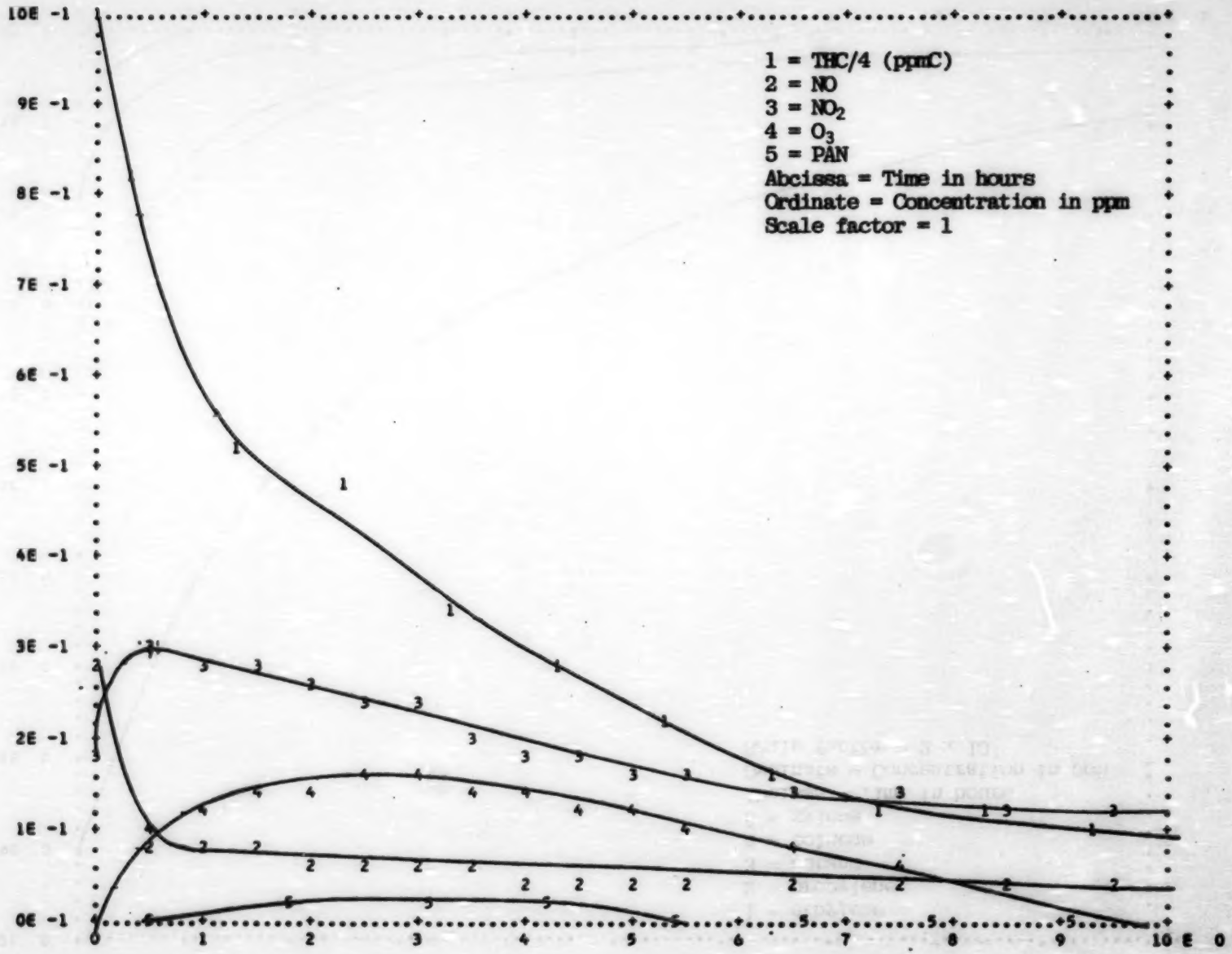
Final Oxidant by Neutral Buffered KI = 0.03 ppm

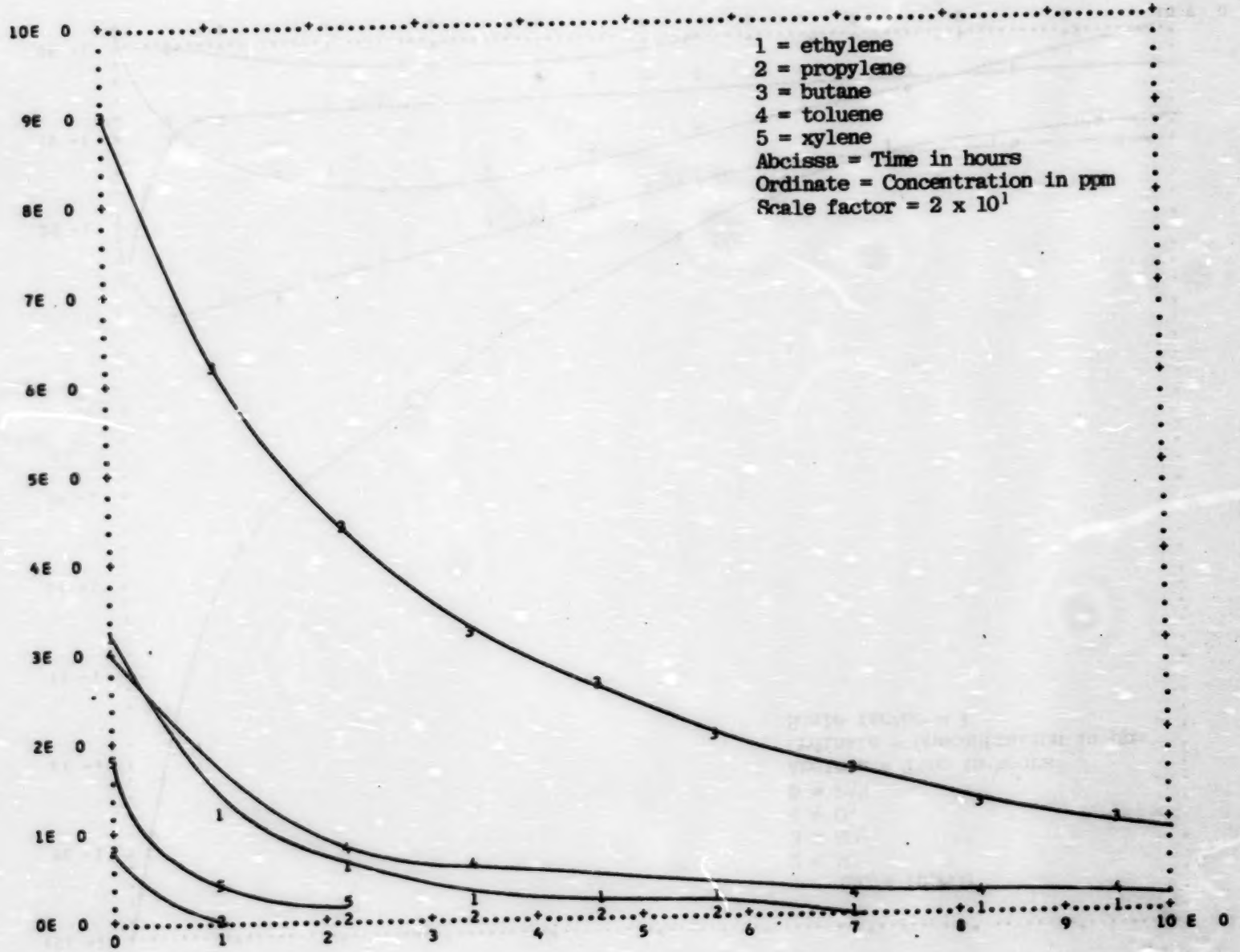
Initial Formaldehyde by Chromatropic Acid = 0 ppm

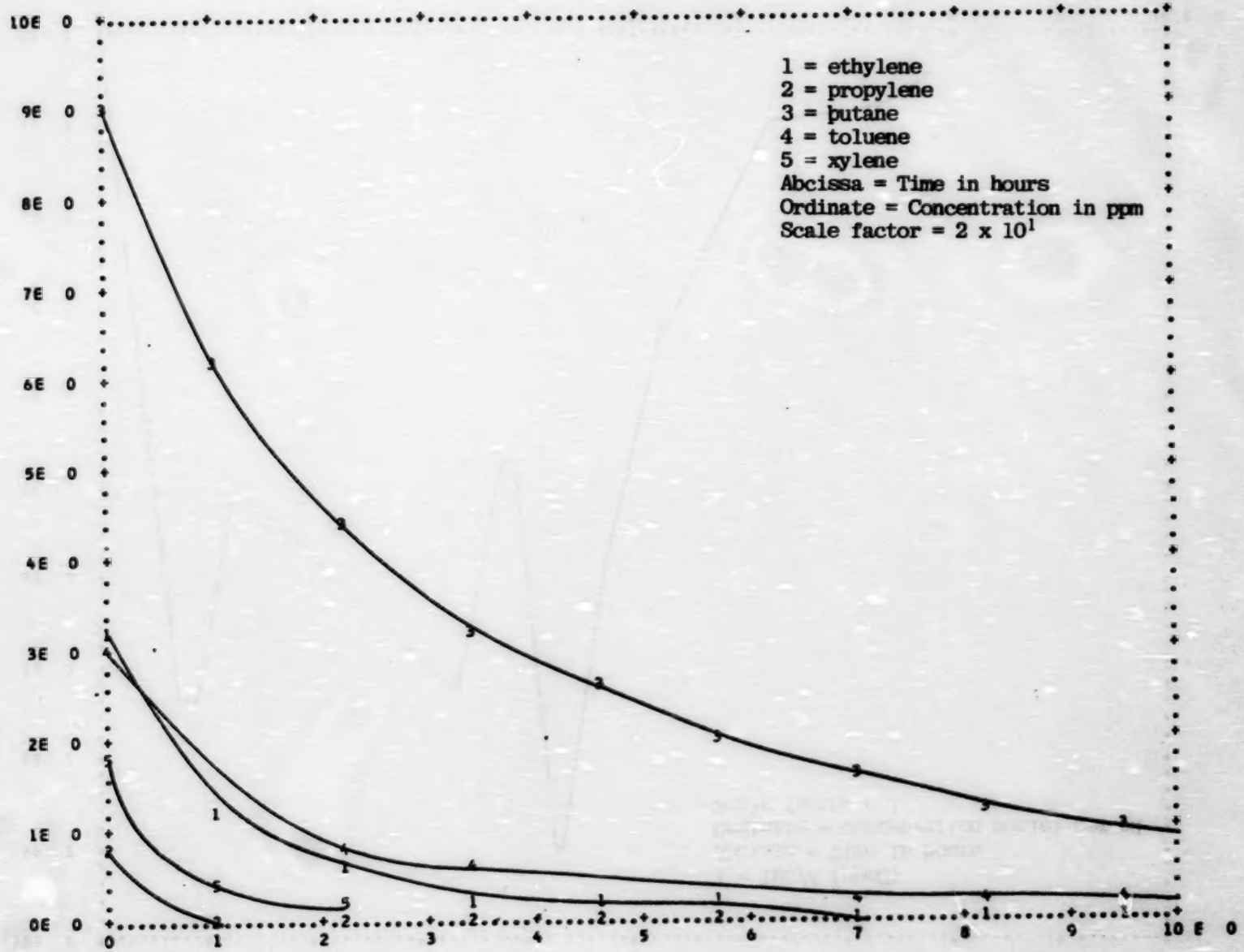
Final Formaldehyde by Chromatropic Acid = 0.06 ppm

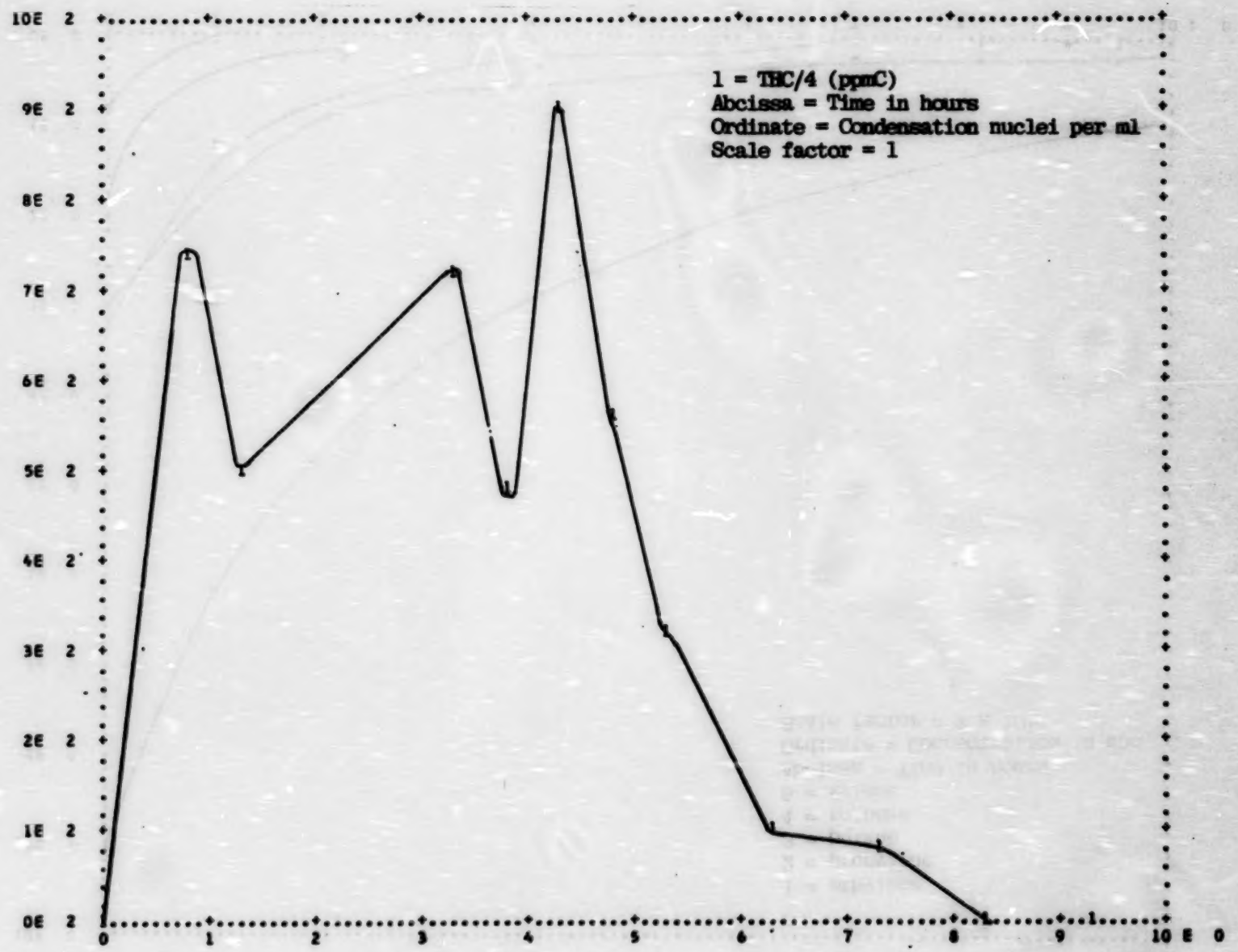
Maximum 1-hour Average O_3 = 0.163 ppm

Maximum 1-hour Average NO_2 = 0.280 ppm


1 = THC/4 (ppmC)
2 = NO
3 = NO2
4 = O3
5 = PAN
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 1
10E -1
9E -1
8E -1
7E -1
6E -1
5E -1
4E -1
3E -1
2E -1
1E -1
0E -1
0
1
2
3
4
5
6
7
8
9
10 E 0


1 = ethylene
2 = propylene
3 = butane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10[1]
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0
1
2
3
4
5
6
7
8
9
10 E 0


1 = ethylene
2 = propylene
3 = butane
4 = toluene
5 = xylene
Abcissa = Time in hours
Ordinate = Concentration in ppm
Scale factor = 2 x 10[1]
10E 0
9E 0
8E 0
7E 0
6E 0
5E 0
4E 0
3E 0
2E 0
1E 0
0E 0
0
1
2
3
4
5
6
7
8
9
10 E 0


1 = THC/4 (ppmC)
Abcissa = Time in hours
Ordinate = Condensation nuclei per ml
Scale factor = 1
10E 2
9E 2
8E 2
7E 2
6E 2
5E 2
4E 2
3E 2
2E 2
1E 2
0E 2
0
1
2
3
4
5
6
7
8
9
10 E 0

APPENDIX D

ANALYSIS OF VARIANCE TABLES

EXPLANATION OF SYMBOLS

Factor	Symbol
Chamber Running Mode	T
HC/NO_x	C
Hydrocarbon Blend	B

Factor	Level 1	Level 2	Level 3
T	static	dilution	dynamic
C	4	8	--
B	XL-228	A-11004	--

PARAMETER: MAXIMUM 1-HOUR AVERAGE O_3

Factor Means for Each Level				Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares
Factor	Level 1	Level 2	Level 3				
T	0.152	0.159	0.245	T	0.04327	2	.02163
C	0.173	0.198		C	0.00352	1	.00352
B	0.232	0.139		TC	0.02106	2	.01053
				B	0.05161	1	.05161
				TB	0.01503	2	.00751
				CB	0.00924	1	.00924
				TCB	0.01641	2	.00820
				Residual	0.03015	12	.00251
				Total	0.19037	23	

PARAMETER: O_3 DOSE

Factor Means for Each Level			
Factor	Level 1	Level 2	Level 3
T	0.827	0.945	1.777
C	1.076	1.289	
B	0.474	0.892	

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares
T	4.28687	2	2.14343
C	0.27200	1	0.27200
TC	0.76750	2	0.38375
B	2.03059	1	2.03059
TB	0.37592	2	0.18796
CB	0.18322	1	0.18322
TCB	0.61150	2	0.30575
Residual	1.37474	12	0.08683
Total	9.90238	23	

PARAMETER: O_3, TIME TO MAXIMUM

Factor Means for Each Level			
Factor	Level 1	Level 2	Level 3
T	8.743	6.618	3.518
C	7.224	5.362	
B	5.404	7.183	

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares
T	110.46995	2	55.23497
C	20.81344	1	20.81344
TC	7.68249	2	3.84124
B	18.99260	1	18.99260
TB	3.96083	2	1.98041
CB	0.29260	1	0.29260
TCB	0.86333	2	0.43166
Residual	5.94621	12	0.4955
Total	169.02133	23	

PARAMETER: NO_2, MAXIMUM 1-HOUR AVERAGE

Factor Means for Each Level			
Factor	Level 1	Level 2	Level 3
T	0.373	0.358	0.378
C	0.452	0.287	
B	0.388	0.352	

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares
T	0.00173	2	0.00086
C	0.16236	1	0.16236
TC	0.01854	2	0.00927
B	0.00784	1	0.00784
TB	0.01252	2	0.00626
CB	0.00035	1	0.00035
TCB	0.00174	2	0.00087
Residual	0.02401	12	0.002001
Total	0.22914	23	

PARAMETER: NO_2 DOSE

Factor Means for Each Level				Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares
Factor	Level 1	Level 2	Level 3				
T	2.541	2.189	1.924	T	1.53308	2	0.76654
C	2.794	1.642		C	7.95225	1	7.95225
B	2.126	2.310		TC	0.60714	2	0.30357
				B	0.20295	1	0.20295
				TB	0.03674	2	0.01837
				CB	0.05870	1	0.05870
				TCB	0.01840	2	0.00920
				Residual	0.53475	12	0.04456
				Total	10.94406	23	

PARAMETER: NO_2, TIME TO MAXIMUM

Factor Means for Each Level				Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares
Factor	Level 1	Level 2	Level 3				
T	2.199	1.762	0.665	T	9.99692	2	4.99846
C	1.781	1.304		C	1.36564	1	1.36564
B	1.385	1.699		TC	0.39880	2	0.19940
				B	0.59377	1	0.59377
				TB	0.41255	2	0.20627
				CB	0.12398	1	0.12398
				TCB	0.47359	2	0.23679
				Residual	12.25152	12	1.02096
				Total	25.61680	23	

PARAMETER: PAN, MAXIMUM

Factor Means for Each Level				Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares
Factor	Level 1	Level 2	Level 3				
T	0.007	0.006	0.019	T	0.00081	2	0.00040
C	0.011	0.011		C	0.00000	1	0.00000
B	0.015	0.007		TC	0.00012	2	0.00006
				B	0.00035	1	0.00035
				TB	0.00000	2	0.00000
				CB	0.00002	1	0.00002
				TCB	0.00013	2	0.00006
				Residual	0.0001	12	0.000083
				Total	0.00157	23	

PARAMETER: OXIDANT, 10 HOUR

Factor Means for Each Level				Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares
Factor	Level 1	Level 2	Level 3				
T	0.119	0.091	0.102	T	0.00335	2	0.00167
C	0.100	0.108		C	0.00033	1	0.00033
B	0.122	0.086		TC	0.00062	2	0.00031
				B	0.00770	1	0.00770
				TB	0.01155	2	0.00577
				CB	0.00920	1	0.00920
				TCB	0.01325	2	0.00662
				Residual	0.0205	12	0.00171
				Total	0.06659	23	

PARAMETER: FORMALDEHYDE, 10 HOUR

Factor Means for Each Level			
Factor	Level 1	Level 2	Level 3
T	0.137	0.088	0.101
C	0.120	0.097	
B	0.123	0.094	

Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares
T	0.01025	2	0.00512
C	0.00326	1	0.00326
TC	0.00175	2	0.00087
B	0.00481	1	0.00481
TB	0.00145	2	0.00072
CB	0.00326	1	0.00326
TCB	0.00425	2	0.00212
Residual	0.02426	12	0.002021
Total	0.05338	23	

PARAMETER: AVERAGE TOTAL HYDROCARBON DISAPPEARANCE RATE

Factor Means for Each Level				Source of Variation	Sums of Squares	Degrees of Freedom	Mean Squares
Factor	Level 1	Level 2	Level 3				
T	0.356	0.437	1.338	T	4.75775	2	2.37887
C	0.694	0.726		C	0.00601	1	0.00601
B	0.879	0.542		TC	0.01560	2	0.00780
				B	0.68006	1	0.68006
				TB	0.20635	2	0.10317
				CB	0.04506	1	0.04506
				TCB	0.20400	2	0.10200
				Residual	0.40045	12	0.033371
				Total	6.31537	23	